



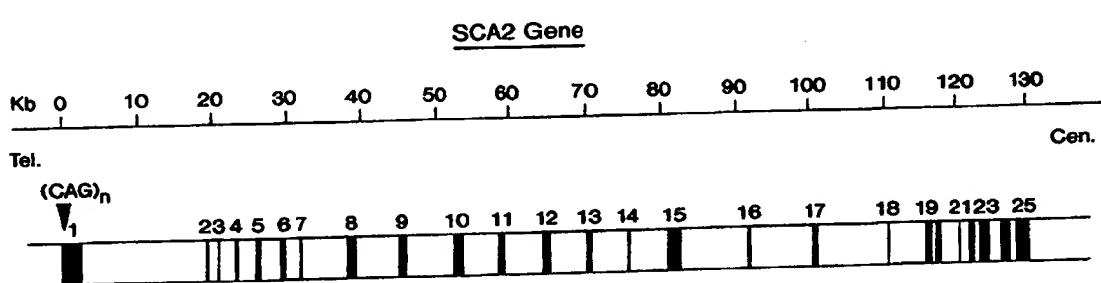
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NUCLEIC ACID ENCODING SPINOCEBELLAR ATAXIA-2 AND PRODUCTS RELATED THERETO



- Largest exon: exon 1, 928 bps: contains CAG repeat
- Largest intron: intron 1 with approximately 15 Kbps
- Smallest exon: exon 2, 37 bps

- Exon sizes:	- known intron sizes:
8<100 bps	intron 2 : 1.6 Kb
100 bps<12<200 bps	intron 19: 0.3 Kb
200 bps< 4<400 bps	intron 22: 1.0 Kb
400 bps< 1	intron 24: 1.6 Kb

(57) Abstract

The present invention provides isolated nucleic acids encoding human SCA2 protein, or fragments thereof, and isolated SCA2 proteins encoded thereby. Further provided are vectors containing invention nucleic acids, probes that hybridize thereto, host cells transformed therewith, antisense oligonucleotides thereto and compositions containing antibodies that specifically bind to invention polypeptides, as well as transgenic non-human mammals that express the invention protein. In addition, methods for diagnosing spinocerebellar Ataxia Type 2 are provided.

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NUCLEIC ACID ENCODING SPINOCEREBELLAR ATAXIA-2
AND PRODUCTS RELATED THERETO

BACKGROUND OF THE INVENTION

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Disorders of the cerebellum and its connections are a major cause of neurologic morbidity and mortality. One of the cardinal features of lesions in these pathways is ataxia or incoordination of movements and gait.

10 Although some of the lesions have obvious etiologies such as trauma, strokes or tumors, the etiology of many ataxias has remained difficult to define and is due to metabolic deficiencies, remote effects of cancer or genetic causes.

15 Hereditary spinocerebellar degenerations have a prevalence of 7 - 20 cases per 100,000 (Filla et al., *J. of Neurology 239(6):351-353* (1992); Polo et al., *Brain 114 (pt2):855-866* (1991)) which equals the estimates for the prevalence of multiple sclerosis in the United States Based on clinical analysis and genetic inheritance patterns several forms of

20 ataxias are now recognized. Among the genetic causes of ataxic disorders, the autosomal dominant spinocerebellar ataxias (SCAs) have been the most difficult to classify and until recently no clues to their cause existed.

25

The SCAs are progressive degenerative neurological diseases of the nervous system characterized by a progressive degeneration of neurons of the cerebellar cortex. Degeneration is also seen in the deep cerebellar nuclei, brain stem, and spinal cord. Clinically, affected 30 individuals suffer from severe ataxia and dysarthria, as well as from variable degrees of motor disturbance and neuropathy. The disease usually results in complete disability and eventually in death 10 to 30 years after onset of symptoms. The genes for SCA types 1 and 3 have 35 been identified. Both contain CAG DNA repeats that cause the disease when expanded. However, little is known how CAG repeat expansion and consequent elongation of

polyglutamine tracts translate into neurodegeneration. The identification of the SCA2 gene would provide the opportunity to study this phenomenon in a new protein system.

5

The significance of identifying ataxia genes goes beyond improved diagnosis for individuals, the possibility of prenatal/presymptomatic diagnosis or better classification of ataxias. Most of the genes associated 10 with repeat expansions in the coding region including the genes for SCA1 and SCA3 are genes that show no homology to known genes. Thus, isolation of these genes will likely point to pathways leading to late-onset neurodegeneration that are novel and may have importance for other 15 neurodegenerative diseases.

For example, it has been suggested that CAG expansion may result in increased transglutamination of proteins, a process that has also been implicated in 20 Alzheimer's disease. The ataxias in particular offer the unique opportunity to study how different genes may either independently or through conjoined action in the same pathway produce relatively similar phenotypes in humans. Therefore, it may be possible to examine the interaction of 25 these genes on age of onset and phenotype, and explain that part of phenotypic variability that is not explained by determining repeat expansion in the mutant allele. Cosmids and YACs have been the main tools for generating contig maps of chromosomal regions and the entire genome, 30 respectively. Recently, novel cloning vectors (reviewed in Ioannou et al., *Nat. Genet.* 6:84-89 (1994)) have been developed that may be more stable than cosmids, while being considerable larger.

35

Several systems of classification have been proposed for the SCAs based on pathological, clinical or genetic criteria. However, these attempts have been

hampered by the extreme variability of disease onset and clinical features within and between families. Among the dominant ataxias only Machado-Joseph disease (MJD) has been clinically defined as a separate disease based on the 5 prominence of basal ganglia involvement. However, since phenotypic variability is remarkable in MJD pedigrees, the assignment of individual cases or small families to this category is difficult. Indeed, after identification of the MJD locus (SCA3) it has become apparent that families with 10 a phenotype not typical of MJD, but resembling SCAs are linked to the same locus as SCA3 families.

The advent of genetic linkage analysis provided a novel means to approach classification of the SCAs. 15 Since the late 70's it was recognized that some SCA pedigrees appeared to show linkage to the HLA locus on CHR6, while others did not. Later this locus, now called SCA1, was further defined using RFLP and microsatellite markers and was mapped centromeric to the HLA locus. After 20 the establishment of flanking markers for the SCA1 gene it became rapidly apparent that many- if not the majority- of SCA families did not show linkage to the SCA1 locus. Recently, a second SCA locus was identified on CHR12 using a large pedigree of Cuban descent (Gispert et al., Nat. 25 Genet. 4:295-299 (1993)) and in a pedigree of Southern Italian origin (Pulst et al., Nat. Genet. 5:8-10 (1993)). At the same time a third locus for Machado-Joseph disease and other pedigrees with an SCA phenotype was identified on CHR14 (Takiyama et al., Nat. Genet. 4:300-304 (1993)). 30 Recently, SCA4 was mapped to CHR16 and SCA5 to CHR11 (Ranum et al., Nat. Genet. 8:N3:280-284 (1994)).

Two of the SCA genes have been identified, one by a positional cloning approach, the other by a cDNA based 35 approach. The SCA1 gene was identified by screening a cosmid contig covering the region between the two flanking

markers D6S274 and D6S89 for cosmids containing CAG repeats. A CAG repeat was isolated, and shown to be expanded in affected individuals (Orr et al., *Nat. Genet.* 4:221-226 (1993); see Table 1). The number of CAG repeats
5 are inversely correlated with the age of onset. Recently, the complete coding sequence for the SCA1 gene has been determined. The gene does not appear to be homologous to other known genes. Despite the tissue specific effects of the mutation, SCA1 transcripts are ubiquitously expressed.
10 By RT-PCR analysis, normal and mutated transcripts are found in tissues indicating that repeat expansion does not interfere with transcription.

The SCA3 or MJD gene was identified after several
15 CAG containing cDNA clones had been isolated from a brain cDNA library (Kawaguchi et al., *Nat. Genet.* 8:221-227 (1994)). One of these mapped to CHR 14q32.1, the region previously identified by genetic linkage analysis to contain the SCA3 gene. The CAG repeat was expanded in
20 affected individuals, but appears to show greater meiotic stability than other CAG repeats. The SCA3 gene has no homology to other known genes or motif structures, but related sequences were identified on CHR 8q23, 14q21, and Xp22.1.

25

Although not an SCA gene in the strict sense, CAG expansion in the gene causing dentatorubral-pallidoluysian atrophy (DRPLA) may also lead to degeneration of cerebellar neurons. This gene was identified by searching published
30 brain cDNA sequences for the presence of CAG repeats. A cDNA mapped to CHR12p was found to harbor a CAG repeat which was expanded in DRPLA patients (Koide et al., *Nat. Genet.* 6:9-13 (1994); Nagafuchi et al., *Nat. Genet.* 6:14-18 (1994)). The gene which has no known homologies is
35 ubiquitously expressed. SCA families linked to markers on CHR 12 have been described in several ethnic backgrounds.

The largest ones are of Cuban ancestry (H pedigree), French-Canadian and Austrian ancestry (SAK and GK pedigrees, Lopes-Cendes et al., *Am. J. Hum. Genet.* 54:774-781 (1994)) and Italian descent (FS pedigree, Pulst et al., 5 (1993)). A smaller Tunisian pedigree has been described as well (Belal et al., *Neurology* 44:1423-1426 (1994)). Although all pedigrees have cases with early onset in recent generations, a formal age of onset analysis has only been performed for the FS pedigree. This analysis 10 indicated clear evidence of anticipation (Pulst et al., (1993)).

The phenomenon of unstable DNA repeats raises many fascinating issues. For example, in 1991, La Spada et 15 al. identified a polymorphic CAG repeat in the androgen receptor gene on the X chromosome that was greatly expanded in individuals with spinobulbar muscular atrophy (SBMA, Kennedy syndrome). In short succession, a total of ten diseases were found to be caused by trinucleotide repeat 20 (TNR) expansion (Table 1). Although several unifying concepts emerge from the comparison of diseases caused by TNR expansion, important differences can be recognized as well.

25 Common to all diseases is a highly polymorphic number of repeats on normal chromosomes. If the repeat number reaches allele sizes in between normal and disease alleles -termed premutations- the repeat becomes unstable and may expand to the size associated with the disease 30 state. Large number repeats have the tendency to expand further, although decreases in size are occasionally seen (Bruner et al., *New Engl. J. Med.* 328:476-480 (1993); reviewed in Brook, *Nat. Genet.* 3:279-152 (1993); Mandel, *Nat. Genet.* 4:8-9 (1993)).

TABLE 1:

Characteristics of diseases caused by TNR expansion

Disease	Type of repeat	Location of repeat	Number of repeats in normal alleles	in disease alleles
5 Fragile X syndrome	CGG	5' untr.	5 - 54	200 - 200
	GCC	unknown	6 - 25	200 - 80
	GCC	unknown	6 - 29	300 - 500
	GCC	unknown	16 - 49	1000 - 20000
10 Myotonic dystrophy	CTG	3' untr.	5 - 35	100 - 200
	CAG	coding	11 - 31	40 - 62
	CAG	coding	15 - 38	38 - 120
	CAG	coding	25 - 36	43 - 81
	CAG	coding	7 - 26	49 - 75
15 MJD (SCA3)	CAG	coding	13 - 36	68 - 79

TNR expansion may be a common form of human mutagenesis. Especially if expansion is not restricted to pure CAG and CGG repeats, the number of genes predisposed to expansion may be quite large. Three diseases with cerebellar degeneration, SCA1, DRPLA, and SCA3 are caused by expansion of a CAG repeat. In these diseases clear evidence of anticipation was lacking, although very early onset cases in some families had raised this question. However, as described in Pulst et al. (1993) strong evidence for anticipation was identified in the FS pedigree with SCA2. Thus, there is a need in the art to identify the location and nucleic acid structure of the SCA2 gene.

SUMMARY OF THE INVENTION

The present invention provides isolated nucleic acids encoding the human SCA2 protein and isolated proteins encoded thereby. Further provided are vectors containing invention nucleic acids, probes that hybridize thereto, host cells transformed therewith, antisense oligonucleotides thereto and compositions containing, antibodies that specifically bind to invention polypeptides and compositions containing, as well as transgenic non-human mammals that express the invention protein. In addition, methods for diagnosing

spinocerebellar Ataxia Type 2, or a presisposition thereto, are provided.

BRIEF DESCRIPTION OF THE FIGURES

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Figure 1 shows a physical map of the SCA2 region. The location of *D12S1328* centromeric and *D12S1329* telomeric of the contig are indicated. As indicated by double forward slashes, the map is not drawn to scale between *D12S1328* and *P46F2t7*, and between *B78E14t7* and *D12S1329*. YAC, PAC and BAC clones are prefixed with 'Y', 'P', and 'B' respectively. Clones positive for a specific STS by PCR analysis are indicated by vertical lines. Solid arrows indicate end-STSs from the clone under the symbol. Sizes of all clones are shown to scale. The chimeric part of YAC clone 856_h_2(1,100 kb) is indicated by a dashed arrow. Interstitial deletions in YACs or PACs are indicated by thin lines in brackets. The extent of the deletion in YAC Y638_e.7 is not precisely known.

10

Figure 2 shows the nucleic acid sequence (SEQ ID NO:1) of plasmid PL65I22B for genomic DNA encoding the expansion of the CAG repeat in individuals with SCA2.

15

Nucleotides 1 - 499 of Figure 2 correspond to cDNA nucleotides 392 - 890 of Figure 6 (SEQ ID NO:2). The locations of primers SCA2-A and SCA2-B are indicated by arrows. The location of a predicted splice site is indicated by a vertical arrow between nucleotides 499 and 500 (also compare with Figure 6).

20

Figure 3 shows an analysis of the SCA2 CAG repeat by polyacrylamide electrophoresis. A common allele of 22 repeats and a less frequent allele of 23 repeats (samples 14 and 15) are seen in normal individuals. SCA2 patients with extended alleles form 37

to 52 repeats are shown. SCA2 patients derive from two pedigrees with CHR 12 linked dominant ataxia. The pedigree structures are shown at the top. Genomic DNAs were amplified with primers SCA2-A and SCA2-B and 5 separated in a 6% polyacrylamide gel. Primer SCA2-A was end-labeled. As a size standard, single stranded M13mp18 control DNA was sequenced with sequencing primer "-40" provided by USB (United States Biochem.).

10 Figure 4 shows a Scattergram indicating that CAG repeat length and age-of-onset of disease in 33 SCA2 patients are inversely correlated.

15 Figure 5 shows four cDNA clones as a schematic of the composite SCA2 cDNA sequence. The thick line corresponds to coding sequence, the thin line to untranslated regions. The location of the CAG repeat is indicated by a hatched box. In clone S2, the repeat was not a CAG, but a CTG repeat followed by 12 bp of sequence 20 not contained in any of the other cDNA clones.

Figure 6 shows the composite cDNA sequence (SEQ ID NO:2) obtained from assembly of the partially overlapping cDNA clones shown in Figure 5. The predicted 25 SCA2 protein product (SEQ ID NO:3) is shown below the DNA sequence. The stop codon for the SCA2 cDNA is indicated by *. The locations of primers SCA2-A, SCA2-B, and SCA2-B14 are indicated by horizontal arrows. The splice site between primers SCA2-B and SCA2-B14 is indicated by a 30 vertical arrow.

Figure 7 shows a partial amino acid sequence alignment comparison of ataxin-2 protein, the ataxin-2 related protein (A2RP), and the mouse SCA2 homologue in 35 the region of strongest homology. Codon 1 corresponds to codon 155 in Figure 6 (SEQ ID NO:3).

Figure 8 shows the genomic structure of the SCA2 gene.

DETAILED DESCRIPTION OF THE INVENTION

5

The hereditary ataxias are a complex group of neurodegenerative disorders all characterized by varying abnormalities of balance attributed to dysfunction or pathology of the cerebellum and cerebellar pathways. In 10 many of these disorders, dysfunction or structural abnormalities extend beyond the cerebellum, and may involve basal ganglia function, oculo-motor disorders and neuropathy. Among the inherited ataxias, the classification of dominant adult onset ataxias is 15 particularly controversial with regard to nomenclature, associated findings and pathology. The dominant spinocerebellar ataxias (SCAs) represent a phenotypically heterogeneous group of disorders with a prevalence of familial cases of approximately 1 per 100,000. This 20 group of disorders is also designated as olivo-ponto-cerebellar atrophies (OPCAs), although this term is too restrictive a pathological label.

25

The high phenotypic variability within single SCA pedigrees has made clinical classification of different forms of ataxia difficult. The gene causing SCA1 has been identified on CHR 6p and the SCA3 gene has been identified on CHR 14q. These diseases are caused by expansion of a CAG repeat in the coding region of the 30 genes. However, many SCA pedigrees do not show linkage to CHR 6p or CHR 14q, confirming the presence of non-allelic heterogeneity. Subsequent genetic linkage studies have led to the identification of SCA loci on CHR12 and some families do not show linkage to either of 35 the above three chromosomal regions.

Described in the instant specification is the construction of the BAC (Bacterial Artificial Chromosome) Shizuya et al., *Proc. Natl. Acad. Sci. USA* 89:8794-8797 (1992) contig and PAC (P1 Artificial Chromosome) of the 5 SCA2 region and the isolation of a novel SCA2 gene from this contiguous map unit using a technique that screens for the presence of DNA trinucleotide repeats.

Sequence analysis of the DNA sequence flanking 10 the CAG repeat revealed an open reading frame of 317 base pairs (Figure 2). A homology search of the amino acid sequence of this open reading frame (ORF) with genes registered in Genbank/EMBL and search of the TIGR database showed no homologous proteins or homologous 15 genomic DNA sequences. Using reverse-transcribed PCR (polymerase chain reaction) with primers SCA1-A and SCA1-B, the genomic sequence containing the CAG repeat was shown to be expressed into mRNA. Subsequently, cDNA encoding human and mouse SCA2 has been isolated as 20 described hereinafter in Examples 4 and 7, respectively.

Accordingly, the present invention provides isolated nucleic acids, which encode a novel mammalian SCA2 protein, and fragments thereof. Such nucleic acids 25 can be obtained, for example, from human chromosome 12, specifically at the q24.1 locus, which is the site of mutation(s) that cause SCA2.

The term "nucleic acids" (also referred to as 30 polynucleotides) encompasses RNA as well as single and double-stranded DNA and cDNA. As used herein, the phrase "isolated" means a nucleic acid that is in a form that does not occur in nature. One means of isolating a nucleic acid encoding an SCA2 polypeptide is to probe a 35 mammalian genomic library with a natural or artificially designed DNA probe using methods well known in the art. DNA probes derived from the SCA2 gene are particularly

useful for this purpose. DNA and cDNA molecules that encode SCA2 polypeptides can be used to obtain complementary genomic DNA, cDNA or RNA from human, mammalian (e.g., mouse, rat, rabbit, pig, and the like), or other animal sources, or to isolate related cDNA or genomic clones by the screening of cDNA or genomic libraries, by methods described in more detail below. Examples of nucleic acids are RNA, cDNA, or isolated genomic DNA encoding an SCA2 polypeptide. Such invention nucleic acids may include, but are not limited to, nucleic acids having substantially the same nucleotide sequence as nucleotides 163-4098 set forth in SEQ ID NO:2 (Figure 6), or at least nucleotides 163-657 or nucleotides 724-4098 of SEQ ID NO:2; or nucleotides 50-3454 of SEQ ID NO:4. In a preferred embodiment, invention nucleic acids include the same nucleotide sequence as nucleotides 163-4098 of SEQ ID NO:2, or include the same nucleotide sequence as nucleotides 50-3454 of SEQ ID NO:4.

20

As employed herein, the phrase "substantially the same nucleotide sequence" refers to DNA having sufficient homology to the reference polynucleotide, such that it will hybridize to the reference nucleotide under typical moderate stringency conditions. In one embodiment, nucleic acid molecules having substantially the same nucleotide sequence as the reference nucleotide sequence encodes substantially the same amino acid sequence as that of either SEQ ID NO:3, or SEQ ID NO:5. In another embodiment, DNA having "substantially the same nucleotide sequence" as the reference nucleotide sequence has at least 60% homology with respect to the reference nucleotide sequence. DNA having at least 70%, more preferably 80%, yet more preferably 90%, homology to the reference nucleotide sequence is preferred.

This invention also encompasses nucleic acids which differ from the nucleic acids shown in SEQ ID NO:1, SEQ ID NO:2, or SEQ ID NO:4, but which have the same phenotype. Phenotypically similar nucleic acids are also referred to as "functionally equivalent nucleic acids". As used herein, the phrase "functionally equivalent nucleic acids" encompasses nucleic acids characterized by slight and non-consequential sequence variations that will function in substantially the same manner to produce the same protein product(s) as the nucleic acids disclosed herein. In particular, functionally equivalent nucleic acids encode polypeptides that are the same as those disclosed herein or that have conservative amino acid variations. For example, conservative variations include substitution of a non-polar residue with another non-polar residue, or substitution of a charged residue with a similarly charged residue. These variations include those recognized by skilled artisans as those that do not substantially alter the tertiary structure of the protein.

Further provided are nucleic acids encoding SCA2 polypeptides that, by virtue of the degeneracy of the genetic code, do not necessarily hybridize to the invention nucleic acids under specified hybridization conditions. Preferred nucleic acids encoding the invention polypeptide are comprised of nucleotides that encode substantially the same amino acid sequence set forth in SEQ ID NO:3 (Figure 6), or SEQ ID NO:5.

30

As employed herein, the term "substantially the same amino acid sequence" refers to amino acid sequences having at least about 70% identity with respect to the reference amino acid sequence, and retaining comparable functional and biological properties characteristic of the protein defined by the reference amino acid sequence. Preferably, proteins having "substantially the same amino

acid sequence" will have at least about 80%, more preferably 90% amino acid identity with respect to the reference amino acid sequence (SEQ ID NO:3 or SEQ ID NO:5); with greater than about 95% amino acid sequence 5 identity being especially preferred.

Alternatively, preferred nucleic acids encoding the invention polypeptide(s) hybridize under moderately stringent, preferably high stringency, conditions to 10 substantially the entire sequence, or substantial portions (i.e., typically at least 15-30 nucleotides) of the nucleic acid sequence set forth in SEQ ID NO:1, SEQ ID NO:2 (Figure 6) or SEQ ID NO:4.

Stringency of hybridization, as used herein, refers to conditions under which polynucleotide hybrids are stable. As known to those of skill in the art, the stability of hybrids is a function of sodium ion concentration and temperature (See, for example, Sambrook 20 et al., *Molecular Cloning: A Laboratory Manual 2d Ed.* (Cold Spring Harbor Laboratory, (1989); incorporated herein by reference). Stringency levels used to hybridize a given probe with target-DNA can be readily varied by those of skill in the art.

As used herein, the phrase "moderately stringent" hybridization refers to conditions that permit target-DNA to bind a complementary nucleic acid that has about 60%, preferably about 75%, more preferably about 30 85%, homology (i.e., identity) to the target DNA; with greater than about 90% homology to target-DNA being especially preferred. Preferably, moderately stringent conditions are conditions equivalent to hybridization in 50% formamide, 5X Denhart's solution, 5X SSPE, 0.2% SDS 35 at 42°C, followed by washing in 0.2X SSPE, 0.2% SDS, at 65°C. Denhart's solution and SSPE (see, e.g., Sambrook et al., *Molecular Cloning, A Laboratory Manual*, Cold Spring

Harbor Laboratory Press, (1989)) are well known to those of skill in the art as are other suitable hybridization buffers.

5 Also provided are isolated SCA2 peptides, polypeptides(s) and/or protein(s), or fragments thereof, encoded by the invention nucleic acids.

As used herein, the term "isolated" means a
10 protein molecule free of cellular components and/or contaminants normally associated with a native *in vivo* environment. Invention polypeptides and/or proteins include any isolated natural occurring allelic variant, as well as recombinant forms thereof. The SCA2
15 polypeptides can be isolated using various methods well known to a person of skill in the art. The methods available for the isolation and purification of invention proteins include, precipitation, gel filtration, ion-exchange, reverse-phase and affinity chromatography.
20 Other well-known methods are described in Deutscher et al., *Guide to Protein Purification: Methods in Enzymology* Vol. 182, (Academic Press, (1990)), which is incorporated herein by reference. Alternatively, the isolated polypeptides of the present invention can be
25 obtained using well-known recombinant methods as described, for example, in Sambrook et al., *supra.*, 1989).

An example of the means for preparing the
30 invention polypeptide(s) is to express nucleic acids encoding the SCA2 in a suitable host cell, such as a bacterial cell, a yeast cell, an amphibian cell (i.e., oocyte), or a mammalian cell, using methods well known in the art, and recovering the expressed polypeptide, again using well-known methods. Invention polypeptides can be isolated directly from cells that have been transformed

with expression vectors, described below in more detail. The invention polypeptide, biologically active fragments, and functional equivalents thereof can also be produced by chemical synthesis. For example, synthetic 5 polypeptides can be produced using Applied Biosystems, Inc. Model 430A or 431A automatic peptide synthesizer (Foster City, CA) employing the chemistry provided by the manufacturer.

10 As used herein, the phrase "SCA2" refers to substantially pure native SCA2 protein, or recombinantly expressed-produced (i.e., isolated or substantially pure) proteins, including variants thereof encoded by mRNA generated by alternative splicing of a primary 15 transcript, and further including fragments thereof which retain native biological activity. Preferred invention polypeptides are those that contain substantially the same amino acid sequence set forth in SEQ ID NO:3 (Figure 6), or at least amino acids 1-165 or amino acids 188-1312 20 of SEQ ID NO:3, or include substantially the same amino acid sequence set forth in SEQ ID NO:5. As used herein, the phrase "functional polypeptide" means a SCA2 that can produce an anti-SCA2 antibody that binds to the native SCA2 protein or to the amino acid sequence set forth in 25 SEQ ID NO:3 (Figure 6), or SEQ ID NO:5. In a preferred embodiment, invention polypeptides include the same amino acid sequence as set forth in SEQ ID NO:3 or SEQ ID NO:5.

Modification of the invention nucleic acids, 30 polypeptides or proteins with the following phrases: "recombinantly expressed/produced", "isolated", or "substantially pure", encompasses nucleic acids, peptides, polypeptides or proteins that have been produced in such form by the hand of man, and are thus 35 separated from their native *in vivo* cellular environment.

As a result of this human intervention, the recombinant nucleic acids, polypeptides and proteins of the invention

are useful in ways that the corresponding naturally occurring molecules are not, such as identification of selective drugs or compounds.

5 Sequences having "substantially the same sequence" homology are intended to refer to nucleotide sequences that share at least about 75%, preferably about 80%, yet more preferably about 90% identity with invention nucleic acids; and amino acid sequences that 10 typically share at least about 75%, preferably about 85%, yet more preferably about 95% amino acid identity with invention polypeptides. It is recognized, however, that polypeptides or nucleic acids containing less than the above-described levels of homology arising as splice 15 variants or that are modified by conservative amino acid substitutions, or by substitution of degenerate codons are also encompassed within the scope of the present invention.

20 The present invention provides the isolated polynucleotide encoding SCA2 operatively linked to a promoter of RNA transcription, as well as other regulatory sequences. As used herein, the phrase "operatively linked" refers to the functional 25 relationship of the polynucleotide with regulatory and effector sequences of nucleotides, such as promoters, enhancers, transcriptional and translational stop sites, and other signal sequences. For example, operative linkage of a polynucleotide to a promoter refers to the 30 physical and functional relationship between the polynucleotide and the promoter such that transcription of DNA is initiated from the promoter by an RNA polymerase that specifically recognizes and binds to the promoter, and wherein the promoter directs the 35 transcription of RNA from the polynucleotide.

Promoter regions include specific sequences that are sufficient for RNA polymerase recognition, binding and transcription initiation. Additionally, promoter regions include sequences that modulate the 5 recognition, binding and transcription initiation activity of RNA polymerase. Such sequences may be *cis* acting or may be responsive to *trans* acting factors. Depending upon the nature of the regulation, promoters may be constitutive or regulated. Examples of promoters 10 are SP6, T4, T7, SV40 early promoter, cytomegalovirus (CMV) promoter, mouse mammary tumor virus (MMTV) steroid-inducible promoter, Moloney murine leukemia virus (MMLV) promoter, and the like.

15 Vectors that contain both a promoter and a cloning site into which a polynucleotide can be operatively linked are well known in the art. Such vectors are capable of transcribing RNA *in vitro* or *in vivo*, and are commercially available from sources such as 20 Stratagene (La Jolla, CA) and Promega Biotech (Madison, WI). In order to optimize expression and/or *in vitro* transcription, it may be necessary to remove, add or alter 5' and/or 3' untranslated portions of the clones to eliminate extra, potential inappropriate alternative 25 translation initiation codons or other sequences that may interfere with or reduce expression, either at the level of transcription or translation. Alternatively, consensus ribosome binding sites can be inserted immediately 5' of the start codon to enhance expression. 30 (See, for example, Kozak, *J. Biol. Chem.* 266:19867 (1991)). Similarly, alternative codons, encoding the same amino acid, can be substituted for coding sequences of the SCA2 polypeptide in order to enhance transcription (e.g., the codon preference of the host cell can be 35 adopted, the presence of G-C rich domains can be reduced, and the like).

Also provided are vectors comprising invention nucleic acids. Examples of vectors are viruses, such as baculoviruses and retroviruses; bacteriophages, cosmids, plasmids and other recombination vehicles typically used 5 in the art. Polynucleotides are inserted into vector genomes using methods well known in the art. For example, insert and vector DNA can be contacted, under suitable conditions, with a restriction enzyme to create complementary ends on each molecule that can pair with 10 each other and be joined together with a ligase. Alternatively, synthetic nucleic acid linkers can be ligated to the termini of restricted polynucleotide. These synthetic linkers contain nucleic acid sequences 15 that correspond to a particular restriction site in the vector DNA.

Additionally, an oligonucleotide containing a termination codon and an appropriate restriction site can be ligated for insertion into a vector containing, for 20 example, some or all of the following: a selectable marker gene, such as the neomycin gene for selection of stable or transient transfecants in mammalian cells; enhancer/promoter sequences from the immediate early gene of human CMV for high levels of transcription; 25 transcription termination and RNA processing signals from SV40 for mRNA stability; SV40 polyoma origins of replication and ColE1 for proper episomal replication; versatile multiple cloning sites; and T7 and SP6 RNA promoters for in vitro transcription of sense and 30 antisense RNA. Other means are well known and available in the art.

Further provided are vectors comprising nucleic acids encoding SCA2 polypeptides, adapted for expression 35 in a bacterial cell, a yeast cell, an amphibian cell (i.e., oocyte), a mammalian cell and other animal cells. The vectors additionally comprise the regulatory elements

necessary for expression of the nucleic acid in the bacterial, yeast, amphibian, mammalian or animal cells so located relative to the nucleic acid encoding SCA2 polypeptide as to permit expression thereof.

5 As used herein, "expression" refers to the process by which nucleic acids are transcribed into mRNA and translated into peptides, polypeptides, or proteins. If the nucleic acid is derived from genomic DNA, 10 expression may include splicing of the mRNA, if an appropriate eucaryotic host is selected. Regulatory elements required for expression include promoter sequences to bind RNA polymerase and transcription initiation sequences for ribosome binding. For example, 15 a bacterial expression vector includes a promoter such as the lac promoter and for transcription initiation the Shine-Dalgarno sequence and the start codon AUG (Sambrook et al. supra). Similarly, a eucaryotic expression vector includes a heterologous or homologous promoter for RNA 20 polymerase II, a downstream polyadenylation signal, the start codon AUG, and a termination codon for detachment of the ribosome. Such vectors can be obtained commercially or assembled by the sequences described in methods well known in the art, for example, the methods 25 described above for constructing vectors in general. Expression vectors are useful to produce cells that express the invention polypeptide.

The present invention provides transformed host 30 cells that recombinantly express SCA2 polypeptides. An example of a transformed host cell is a mammalian cell comprising a plasmid adapted for expression in a mammalian cell. The plasmid contains nucleic acid encoding an SCA2 polypeptide and the regulatory elements 35 necessary for expression of invention proteins. Various mammalian cells may be utilized as hosts, including, for example, mouse fibroblast cell NIH3T3, CHO cells, HeLa

cells, Ltk- cells, etc. Expression plasmids such as those described *supra* can be used to transfect mammalian cells by methods well known in the art such as, for example, calcium phosphate precipitation, DEAE-dextran, 5 electroporation, microinjection or lipofection.

The present invention provides nucleic acid probes comprising nucleotide sequences capable of specifically hybridizing with sequences included within 10 nucleic acids encoding SCA2 polypeptides, for example, a coding sequence included within the nucleotide sequence shown in SEQ ID NO:2 (Figure 6), or SEQ ID NO:4. In a preferred embodiment, the probe is derived from the nucleic acid sequence set forth in SEQ ID NO:2, or at 15 least nucleotides 163-657 or nucleotides 724-4098 of SEQ ID NO:2; or SEQ ID NO:4. Preferred regions from which to construct probes include 5' and/or 3' coding sequences, sequences within the ORF, and the like. Full-length or fragments of cDNA clones encoding SCA2 can also 20 be used as probes for the detection and isolation of related genes. As used herein, an invention "probe" or invention oligonucleotide is a single-stranded DNA or RNA that has a sequence of nucleotides that includes at least about 15 contiguous bases up to the full length coding 25 region of SEQ ID NO:2 or SEQ ID NO:4. Preferably an invention probe is at least about 30 contiguous bases, more preferably at least about 50, yet more preferably at least about 100, with about 300 contiguous bases up to the full length coding region of SEQ ID NO:2 and SEQ ID 30 NO:4 being especially preferred. When fragments are used as probes, preferably the cDNA sequences will be from the carboxyl end-encoding portion of the cDNA, and most preferably will include predicted transmembrane domain-encoding portions of the cDNA sequence. Transmembrane 35 domain regions can be predicted based on hydropathy analysis of the deduced amino acid sequence using, for

example, the method of Kyte and Doolittle, *J. Mol. Biol.* 157:105 (1982).

As used herein, the phrase "specifically hybridizing" encompasses the ability of a polynucleotide to recognize a sequence of nucleic acids that are complementary thereto and to form double-helical segments via hydrogen bonding between complementary base pairs. Nucleic acid probe technology is well known to those skilled in the art who will readily appreciate that such probes may vary greatly in length and may be labeled with a detectable agent, such as a radioisotope, a fluorescent dye, and the like, to facilitate detection of the probe. Invention probes are useful to detect the presence of nucleic acids encoding the SCA2 polypeptide. For example, the probes can be used for *in situ* hybridizations in order to locate biological tissues in which the invention gene is expressed. Additionally, synthesized oligonucleotides complementary to the nucleic acids of a nucleotide sequence encoding SCA2 polypeptide are useful as probes for detecting the invention genes, their associated mRNA, or for the isolation of related genes using homology screening of genomic or cDNA libraries, or by using amplification techniques well known to one of skill in the art.

Also provided are antisense oligonucleotides having a sequence capable of binding specifically with any portion of an mRNA that encodes SCA2 polypeptides so as to prevent or inhibit translation of the mRNA. The antisense oligonucleotide may have a sequence capable of binding specifically with any portion of the sequence of the cDNA encoding SCA2 polypeptides. As used herein, the phrase "binding specifically" encompasses the ability of a nucleic acid sequence to recognize a complementary nucleic acid sequence and to form double-helical segments therewith via the formation of hydrogen bonds between the

complementary base pairs. An example of an antisense oligonucleotide is an antisense oligonucleotide comprising chemical analogs of nucleotides.

5 Compositions comprising an amount of the antisense oligonucleotide, described above, effective to reduce expression of SCA2 polypeptides by passing through a cell membrane and binding specifically with mRNA encoding SCA2 polypeptides so as to prevent translation
10 and an acceptable hydrophobic carrier capable of passing through a cell membrane are also provided herein. The acceptable hydrophobic carrier capable of passing through cell membranes may also comprise a structure which binds to a receptor specific for a selected cell type and is
15 thereby taken up by cells of the selected cell type. The structure may be part of a protein known to bind to a cell-type specific receptor.

Antisense oligonucleotide compositions are
20 useful to inhibit translation of mRNA encoding invention polypeptides. Synthetic oligonucleotides, or other antisense chemical structures are designed to bind to mRNA encoding SCA2 polypeptides and inhibit translation of mRNA and are useful as compositions to inhibit
25 expression of SCA2 associated genes in a tissue sample or in a subject.

In accordance with another embodiment of the invention, kits for detecting mutations and aneuploidies
30 in chromosome 12 at locus q24.1 comprising at least one invention probe or antisense nucleotide.

The present invention provides means to modulate levels of expression of SCA2 polypeptides by
35 employing synthetic antisense oligonucleotide compositions (hereinafter SAOC) which inhibit translation of mRNA encoding these polypeptides. Synthetic

oligonucleotides, or other antisense chemical structures designed to recognize and selectively bind to mRNA, are constructed to be complementary to portions of the SCA2 coding strand or nucleotide sequences shown in SEQ ID NO:2, or SEQ ID NO:4. The SAOC is designed to be stable in the blood stream for administration to a subject by injection, or in laboratory cell culture conditions. The SAOC is designed to be capable of passing through the cell membrane in order to enter the cytoplasm of the cell by virtue of physical and chemical properties of the SAOC which render it capable of passing through cell membranes, for example, by designing small, hydrophobic SAOC chemical structures, or by virtue of specific transport systems in the cell which recognize and transport the SAOC into the cell. In addition, the SAOC can be designed for administration only to certain selected cell populations by targeting the SAOC to be recognized by specific cellular uptake mechanisms which bind and take up the SAOC only within select cell populations.

For example, the SAOC may be designed to bind to a receptor found only in a certain cell type, as discussed *supra*. The SAOC is also designed to recognize and selectively bind to target mRNA sequence, which may correspond to a sequence contained within the sequence shown in SEQ ID NO:2, or SEQ ID NO:4. The SAOC is designed to inactivate target mRNA sequence by either binding thereto and inducing degradation of the mRNA by, for example, RNase I digestion, or inhibiting translation of mRNA target sequence by interfering with the binding of translation-regulating factors or ribosomes, or inclusion of other chemical structures, such as ribozyme sequences or reactive chemical groups which either degrade or chemically modify the target mRNA. SAOCs have been shown to be capable of such properties when directed against mRNA targets (see Cohen et al., *TIPS*, 10:435

(1989) and Weintraub, *Sci. American*, January (1990), pp. 40; both incorporated herein by reference).

The present invention also provides
5 compositions containing an acceptable carrier and any of
an isolated, purified SCA2 polypeptide, an active
fragment thereof, or a purified, mature protein and
active fragments thereof, alone or in combination with
each other. These polypeptides or proteins can be
10 recombinantly derived, chemically synthesized or purified
from native sources. As used herein, the term
"acceptable carrier" encompasses any of the standard
pharmaceutical carriers, such as phosphate buffered
saline solution, water and emulsions such as an oil/water
15 or water/oil emulsion, and various types of wetting
agents.

Further provided are anti-SCA2 antibodies
having specific reactivity with SCA2 polypeptides of the
20 present invention. Active fragments of antibodies are
encompassed within the definition of "antibody".
Invention antibodies can be produced by methods known in
the art using invention polypeptides, proteins or
portions thereof as antigens. For example, polyclonal
25 and monoclonal antibodies can be produced by methods well
known in the art, as described, for example, in Harlow
and Lane, *Antibodies: A Laboratory Manual* (Cold Spring
Harbor Laboratory (1988)), which is incorporated herein
by reference. Invention polypeptides can be used as
30 immunogens in generating such antibodies. Alternatively,
synthetic peptides can be prepared (using commercially
available synthesizers) and used as immunogens. Amino
acid sequences can be analyzed by methods well known in
the art to determine whether they encode hydrophobic or
35 hydrophilic domains of the corresponding polypeptide.
Altered antibodies such as chimeric, humanized, CDR-
grafted or bifunctional antibodies can also be produced

by methods well known in the art. Such antibodies can also be produced by hybridoma, chemical synthesis or recombinant methods described, for example, in Sambrook et al., *supra.*, and Harlow and Lane, *supra*. Both anti-peptide and anti-fusion protein antibodies can be used. (see, for example, Bahouth et al., *Trends Pharmacol. Sci.* 12:338 (1991); Ausubel et al., *Current Protocols in Molecular Biology* (John Wiley and Sons, NY (1989) which are incorporated herein by reference).

10

Invention antibodies also can be used to isolate invention polypeptides. Additionally the antibodies are useful for detecting the presence of invention polypeptides, as well as analysis of chromosome localization, and structural as well as functional domains. Methods for detecting the presence of SCA2 polypeptides on the surface of a cell comprise contacting the cell with an antibody that specifically binds to SCA2 polypeptides, under conditions permitting binding of the antibody to the polypeptides, detecting the presence of the antibody bound to the cell, and thereby detecting the presence of invention polypeptides on the surface of the cell. With respect to the detection of such polypeptides, the antibodies can be used for *in vitro* diagnostic or *in vivo* imaging methods.

Immunological procedures useful for *in vitro* detection of target SCA2 polypeptides in a sample include immunoassays that employ a detectable antibody. Such immunoassays include, for example, ELISA, Pandex microfluorimetric assay, agglutination assays, flow cytometry, serum diagnostic assays and immunohistochemical staining procedures which are well known in the art. An antibody can be made detectable by various means well known in the art. For example, a detectable marker can be directly or indirectly attached

to the antibody. Useful markers include, for example, radionucleotides, enzymes, fluorogens, chromogens and chemiluminescent labels.

5 Further, invention antibodies can be used to modulate the activity of the SCA2 polypeptide in living animals, in humans, or in biological tissues or fluids isolated therefrom. Accordingly, compositions comprising a carrier and an amount of an antibody having specificity 10 for SCA2 polypeptides effective to block binding of naturally occurring ligands to invention polypeptides. A monoclonal antibody directed to an epitope of SCA2 polypeptide molecules present on the surface of a cell and having an amino acid sequence substantially the same 15 as an amino acid sequence for a cell surface epitope of an SCA2 polypeptide shown in SEQ ID NO:3, or SEQ ID NO:5, can be useful for this purpose.

The present invention further provides 20 transgenic non-human mammals that are capable of expressing nucleic acids encoding SCA2 polypeptides. Also provided are transgenic non-human mammals capable of expressing nucleic acids encoding SCA2 polypeptides so mutated as to be incapable of normal activity, i.e., do 25 not express native SCA2. The present invention also provides transgenic non-human mammals having a genome comprising antisense nucleic acids complementary to nucleic acids encoding SCA2 polypeptides so placed as to be transcribed into antisense mRNA complementary to mRNA 30 encoding SCA2 polypeptides, which hybridizes thereto and, thereby, reduces the translation thereof. The nucleic acid may additionally comprise an inducible promoter and/or tissue specific regulatory elements, so that expression can be induced, or restricted to specific cell 35 types. Examples of nucleic acids are DNA or cDNA having a coding sequence substantially the same as the coding sequence shown in SEQ ID NO:2, or SEQ ID NO:4. An

example of a non-human transgenic mammal is a transgenic mouse. Examples of tissue specificity-determining elements are the metallothionein promoter and the L7 promoter.

5

Animal model systems which elucidate the physiological and behavioral roles of SCA2 polypeptides are produced by creating transgenic animals in which the expression of the SCA2 polypeptide is altered using a variety of techniques. Examples of such techniques include the insertion of normal or mutant versions of nucleic acids encoding an SCA2 polypeptide by microinjection, retroviral infection or other means well known to those skilled in the art, into appropriate fertilized embryos to produce a transgenic animal. (See, for example, Hogan et al., *Manipulating the Mouse Embryo: A Laboratory Manual* (Cold Spring Harbor Laboratory, (1986)).

20

Another technique, homologous recombination of mutant or normal versions of these genes with the native gene locus in transgenic animals, may be used to alter the regulation of expression or the structure of SCA2 polypeptides (see, Capecchi et al., *Science* 244:1288 (1989); Zimmer et al., *Nature* 338:150 (1989); which are incorporated herein by reference). Homologous recombination techniques are well known in the art. Homologous recombination replaces the native (endogenous) gene with a recombinant or mutated gene to produce an animal that cannot express native (endogenous) protein but can express, for example, a mutated protein which results in altered expression of SCA2 polypeptides.

In contrast to homologous recombination, microinjection adds genes to the host genome, without removing host genes. Microinjection can produce a

transgenic animal that is capable of expressing both endogenous and exogenous SCA2 protein. Inducible promoters can be linked to the coding region of nucleic acids to provide a means to regulate expression of the transgene. Tissue specific regulatory elements can be linked to the coding region to permit tissue-specific expression of the transgene. Transgenic animal model systems are useful for *in vivo* screening of compounds for identification of specific ligands, i.e., agonists and antagonists, which activate or inhibit protein responses.

Invention nucleic acids, oligonucleotides (including antisense), vectors containing same, transformed host cells, polypeptides and combinations thereof, as well as antibodies of the present invention, can be used to screen compounds *in vitro* to determine whether a compound functions as a potential agonist or antagonist to invention polypeptides. These *in vitro* screening assays provide information regarding the function and activity of invention polypeptides, which can lead to the identification and design of compounds that are capable of specific interaction with one or more types of polypeptides, peptides or proteins.

In accordance with still another embodiment of the present invention, there is provided a method for identifying compounds which bind to SCA2 polypeptides. The invention proteins may be employed in a competitive binding assay. Such an assay can accommodate the rapid screening of a large number of compounds to determine which compounds, if any, are capable of binding to SCA2 proteins. Subsequently, more detailed assays can be carried out with those compounds found to bind, to further determine whether such compounds act as modulators, agonists or antagonists of invention proteins.

In another embodiment of the invention, there is provided a bioassay for identifying compounds which modulate the activity of invention polypeptides. According to this method, invention polypeptides are 5 contacted with an "unknown" or test substance (in the presence of a reporter gene construct when antagonist activity is tested), the activity of the polypeptide is monitored subsequent to the contact with the "unknown" or test substance, and those substances which cause the 10 reporter gene construct to be expressed are identified as functional ligands for SCA2 polypeptides.

In accordance with another embodiment of the present invention, transformed host cells that 15 recombinantly express invention polypeptides can be contacted with a test compound, and the modulating effect(s) thereof can then be evaluated by comparing the SCA2-mediated response (via reporter gene expression) in the presence and absence of test compound, or by 20 comparing the response of test cells or control cells (i.e., cells that do not express SCA2 polypeptides), to the presence of the compound.

As used herein, a compound or a signal that 25 "modulates the activity" of invention polypeptides refers to a compound or a signal that alters the activity of SCA2 polypeptides so that the activity of the invention polypeptide is different in the presence of the compound or signal than in the absence of the compound or signal. 30 In particular, such compounds or signals include agonists and antagonists. An agonist encompasses a compound or a signal that activates SCA2 protein expression. Alternatively, an antagonist includes a compound or signal that interferes with SCA2 protein expression. 35 Typically, the effect of an antagonist is observed as a blocking of agonist-induced protein activation. Antagonists include competitive and non-competitive

antagonists. A competitive antagonist (or competitive blocker) interacts with or near the site specific for agonist binding. A non-competitive antagonist or blocker inactivates the function of the polypeptide by 5 interacting with a site other than the agonist interaction site.

As understood by those of skill in the art, assay methods for identifying compounds that modulate 10 SCA2 activity generally require comparison to a control. One type of a "control" is a cell or culture that is treated substantially the same as the test cell or test culture exposed to the compound, with the distinction that the "control" cell or culture is not exposed to the 15 compound. For example, in methods that use voltage clamp electrophysiological procedures, the same cell can be tested in the presence or absence of compound, by merely changing the external solution bathing the cell. Another type of "control" cell or culture may be a cell or 20 culture that is identical to the transfected cells, with the exception that the "control" cell or culture do not express native proteins. Accordingly, the response of the transfected cell to compound is compared to the response (or lack thereof) of the "control" cell or 25 culture to the same compound under the same reaction conditions.

In yet another embodiment of the present invention, the activation of SCA2 polypeptides can be 30 modulated by contacting the polypeptides with an effective amount of at least one compound identified by the above-described bioassays.

In accordance with another embodiment of the 35 present invention, there are provided methods for diagnosing spinocerebellar Ataxia Type 2, said method comprising:

detecting, in said subject, a genomic or transcribed mRNA sequence having an expanded CAG repeat at a location corresponding to between nucleotides 657 and 724 of SEQ ID NO:2 (Figure 6).

The number of CAG repeats required to indicate spinocerebellar Ataxia Type 2 is substantially above normal, preferably at least about 10-15 CAG repeats above normal, with at least 13 CAG repeats above normal being especially preferred. A normal amount of CAG repeats in the SCA2 gene (SEQ ID NO:2) has been found to be about 22, while 23 CAG repeats is occasionally observed. Thus, in a preferred diagnostic method, at least about 35 CAG repeats are detected between nucleotides 657 and 724 of SEQ ID NO:2 (Figure 6), with the detection of 37 CAG repeats being especially preferred.

Although expansion of trinucleotide repeats is now recognized as an important mutational mechanism in humans and SCA2 represents the 6th disease in which expansion of a CAG trinucleotide repeat causes disease, there are several features of the SCA2 repeat that appear to be unique. In the other five CAG expansion diseases, the CAG repeats on normal chromosomes are highly polymorphic. Multiple alleles are detected and repeat sizes on normal chromosomes range from a low of 7 repeats in DRPLA to 40 repeats in SCA3/MJD. Heterozygosity for these CAG repeats in the normal population are in the range of 0.80 and above. It has been suggested that the extended normal alleles represent founder alleles which are predisposed to expansion.

The SCA2 repeat is highly unusual, because only two alleles are observed in the normal population. A common allele with 22 repeats is found on 92% of chromosomes, a rare second allele in 8% of chromosomes.

Expansion of the SCA2 CAG repeat on disease chromosomes is relatively moderate and is in the range seen with expansions in the SBMA and Huntington's Disease (HD) genes. The lowest number of repeats causing SCA2 was 36 5 and the most common disease allele had 37 repeats. Disease alleles showing 36 repeats have now clearly been established for HD (Rubinsztein et al., 1996, Am. J. Hum. Genet., 59:16-22), although normal elderly individuals with 10 36-40 repeats exist and the most common HD alleles have >40 repeats. In contrast to SCA1, where normal and disease alleles may differ by only one repeat unit, the longest normal and the shortest SCA2 disease allele are separated by 13 repeats. Once expanded on disease 15 chromosomes, the SCA2 repeat may undergo moderate expansions.

The SCA2 repeat is contained in a novel gene which is transcribed in several tissues including non-neuronal tissues. The gene product, ataxin-2, has a predicted molecular weight of 140 kDa which is in good agreement with the 150 kDa protein observed using a monoclonal antibody to long polyglutamine tracts. A similar pattern of nearly ubiquitous expression has been observed in the other five polyglutamine diseases. 25 Despite the phenotypic overlap of SCA2 with SCA1 and SCA3, the SCA2 gene shows no homology to these genes.

However, ataxin-2 showed significant homologies with another protein (referred to as "A2RP"; see Figure 30 7). A 42 amino acid domain was identified that was 86% identical between the two proteins. The potential functional importance of this domain was underscored by the fact that it was 100% conserved in the mouse SCA2 35 homologue (Figure 7). Interestingly, the polyglutamine tract was not conserved in either protein. Since the pathogenesis of polyglutamine containing proteins is still poorly understood, the identification of

functionally important domains adjacent to polyglutamine tracts may provide the potential for novel strategies to analyze the function of ataxin-2. A gain of function for the mutated ataxin-2 is supported by the fact that
5 transcripts coding for mutated alleles are detected by RT-PCR.

Expansion of the SCA2 repeat appears to be a common cause of a dominant SCA phenotype in non-
10 Portuguese patients. When samples from 45 families with SCA were screened, samples from 8 independent pedigrees showed expansion of the SCA2 repeat. It has been suggested that there are features specific to SCA2, but this assessment was limited to families large enough to
15 be studied by linkage analysis. A better assessment of the range of SCA2 phenotypes is now possible due to the ability to test small families and single cases. In our patient sample, most patients had a 'typical' SCA phenotype, but some patients had been classified as
20 having an MJD phenotype and others showed a prominent dementia.

When performing direct testing for SCA2 mutations, great caution has to be exercised when
25 interpreting the presence of expanded SCA2 alleles on polyacrylamide gels. A variable number of unrelated PCR fragments may be seen that are in the size range of expanded SCA2 repeats. Although these bands lack the typical 'shadow' bands seen when di- or trinucleotide
30 repeats are amplified, they may interfere with the interpretation in some samples. It is therefore recommended to confirm the presence of an expanded allele by Southern blotting and hybridization with a (CAG)₁₀ oligonucleotide.

In yet another embodiment of the present invention, there are provided methods for diagnosing spinocerebellar Ataxia Type 2, said method comprising:

- a) contacting nucleic acid obtained from 5 a subject suspected of having SCA2 with primers that amplify at least a nucleic acid fragment of SEQ ID NO:2 containing nucleotides 658-723 of SEQ ID NO:2, under conditions suitable to form a detectable amplification product; and
- 10 b) detecting an amplification product containing substantially expanded CAG repeats above normal, whereby said detection indicates that said subject has SCA2.

15 As indicated above, substantially expanded CAG repeats have at least about 10-15 CAG repeats above normal, with at least 13 CAG repeats above normal being especially preferred. Thus, in a preferred diagnostic method, at least about 35 CAG repeats are detected 20 between nucleotides 657 and 724 of SEQ ID NO:2 (Figure 6), with the detection of 37 CAG repeats being especially preferred.

In accordance with another embodiment of the 25 present invention, there are provided diagnostic systems, preferably in kit form, comprising at least one invention nucleic acid in a suitable packaging material. In one embodiment, the diagnostic nucleic acids are derived from SEQ ID NO:2 (Figure 6), preferably derived from 30 nucleotides 163-657 and nucleotides 724-4098, with primers SCA2-A and SCA2-B being especially preferred. In another embodiment, the diagnostic nucleic acids are derived from SEQ ID NO:4. Invention diagnostic systems are useful for assaying for the presence or absence of 35 the extended CAG repeat sequence between nucleotides 657 and 724 of SEQ ID NO:2 in the SCA2 gene in either genomic

DNA or in transcribed nucleic acid (such as mRNA or cDNA) encoding SCA2.

A suitable diagnostic system includes at least
5 one invention nucleic acid, preferably two or more
invention nucleic acids, as a separately packaged
chemical reagent(s) in an amount sufficient for at least
one assay. Instructions for use of the packaged reagent
are also typically included. Those of skill in the art
10 can readily incorporate invention nucleic probes and/or
primers into kit form in combination with appropriate
buffers and solutions for the practice of the invention
methods as described herein.

15 As employed herein, the phrase "packaging
material" refers to one or more physical structures used
to house the contents of the kit, such as invention
nucleic acid probes or primers, and the like. The
packaging material is constructed by well known methods,
20 preferably to provide a sterile, contaminant-free
environment. The packaging material has a label which
indicates that the invention nucleic acids can be used
for detecting a particular extended CAG repeat sequence
between the region of genomic DNA corresponding to
25 nucleotides 657 and 724 of SEQ ID NO:2 (Figure 6),
thereby diagnosing the presence of, or a predisposition
for, spinocerebellar ataxia type 2. In addition, the
packaging material contains instructions indicating how
the materials within the kit are employed both to detect
30 a particular sequence and diagnose the presence of, or a
predisposition for, spinocerebellar ataxia type 2.

The packaging materials employed herein in
relation to diagnostic systems are those customarily
35 utilized in nucleic acid-based diagnostic systems. As
used herein, the term "package" refers to a solid matrix
or material such as glass, plastic, paper, foil, and the

like, capable of holding within fixed limits an isolated nucleic acid, oligonucleotide, or primer of the present invention. Thus, for example, a package can be a glass vial used to contain milligram quantities of a contemplated nucleic acid, oligonucleotide or primer, or it can be a microtiter plate well to which microgram quantities of a contemplated nucleic acid probe have been operatively affixed.

10 "Instructions for use" typically include a tangible expression describing the reagent concentration or at least one assay method parameter, such as the relative amounts of reagent and sample to be admixed, maintenance time periods for reagent/sample admixtures, 15 temperature, buffer conditions, and the like.

All U.S. patents and all publications mentioned herein are incorporated in their entirety by reference thereto. The invention will now be described in greater 20 detail by reference to the following non-limiting examples.

The invention will now be described in greater detail with reference to the following non-limiting 25 examples.

Materials and Methods

Unless otherwise stated, the present invention 30 was performed using standard procedures, as described, for example in Maniatis et al., *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York, USA (1982); Sambrook et al., *Molecular Cloning: A Laboratory Manual* (2 ed.), Cold 35 Spring Harbor Laboratory Press, Cold Spring Harbor, New York, USA (1989); Davis et al., *Basic Methods in*

Molecular Biology, Elsevier Science Publishing, Inc., New York, USA (1986); or Methods in Enzymology: Guide to Molecular Cloning Techniques Vol.152, S. L. Berger and A. R. Kimmerl Eds., Academic Press Inc., San Diego, USA 5 (1987)).

Libraries. Yeast artificial chromosome (YAC) clones were obtained from the CEPH mega-YAC library and grown under standard conditions (Cohen et al., Nature 10 366:689-701 (1993)). P1 artificial chromosome (PAC) library construction. A 3X human PAC library, designated RPCI-1 (Ioannou et al., Hum. Genet. 219-220 (1994b)) was constructed as described (Ioannou et al., Nat. Genet. 6:84-89 (1994a)). The library was arrayed in 384 well 15 dishes. Pools from portion of the library were screened by PCR with AFM154TC5 (D12S1333) and AFMa128yf1 (D12S1332). Subsequently, STSS generated by sequencing of clones using vector primers were used as hybridization probes to gridded colony filters of the PAC library.

20

YAC DNA preparation. YAC clones were grown in selective media, pelleted and resuspended in 3 ml 0.9 M sorbitol, 0.1M EDTA pH 7.5, then incubated with 100 U of lytocase (Sigma) at 37°C for 1 hour. After centrifugation 25 for 5 minutes at 5,000 rpm pellets were resuspended in 3 ml 50 mM Tris pH 7.45, 20 mM EDTA three-tenth ml 10% SDS was added and the mixture was incubated at 65°C for 30 minutes. One ml of 5 M potassium acetate was added and tubes were left on ice for 1 hour, then centrifuged at 30 10,000 rpm for 10 minutes. Supernatant was precipitated in 2 volumes of ethanol and pelleted at 6,000 rpm for 15 minutes. Pellets were resuspended in TE, treated with RNase and reextracted with phenol-chloroform.

Analysis by pulsed-field gel electrophoresis.

Agarose plugs of yeast cells containing total YAC DNA were prepared (Larin and Lehrach, *Genet. Rcs.* **56**:203-208 (1990)) and subjected to pulsed-field gel separation on 5 1% SeaKem agarose gels in 0.5X TBE using the CHEF DRII Mapper (Bio-Rad). PAC and BAC clones were sized after digestion with XbaI and NotI. Gels were blotted onto Magna NT Nylon membranes using alkaline blotting, UV cross linked and baked at 80°C for two hours. Membranes 10 were hybridized with total human DNA, washed according to standard procedures, and exposed to Kodak XAR5 film. The sizes of individual clones were determined by comparison to their relative positions with molecular weight standards.

15

Analysis by fluorescence in situ hybridization (FISH). PAC or BAC clones were biotinylated by nicktranslation in the presence of biotin-14-dATP using the BioNick Labeling Kit (Gibco-BRL). FISH was performed 20 essentially as described (Korenberg et al., *Cytogenet Cell Genet.* **69**:196-200 (1995)). Briefly, 400 ng of probe DNA was mixed with 8 ng of human Cot 1 DNA (Gibco-BRL) and 2 ug of sonicated salmon sperm DNA in order to suppress possible background produced from repetitive 25 human sequences as well as yeast sequences in the probe. The probes were denatured at 75°C, preannealed at 37°C for one hour, and applied to denatured chromosome slides prepared from normal male lymphocytes (Korenberg et al., 1995, supra). Post-hybridization washes were performed 30 at 40°C in 2X SSC/50% formamide followed by washes in 1X SSC at 50°C. Hybridized DNAs were detected with avidin-conjugated fluorescent isothiocyanate (Vector Laboratories). One amplification was performed by using biotinylated anti-avidin. For distinguishing chromosome 35 subbands precisely, a reverse banding technique was used, which was achieved by chromomycin A3 and distamycin A

double staining (Korenberg et al., 1995, *supra*). The color images were captured by using a Photometrics Cooled-CCD camera and BDS image analysis software (Oncor Imaging, Inc.).

5

PAC and BAC DNA preparation. Selected clones were grown overnight in LB media containing 12.5 µg/ml kanamycin for PACs and 12.5 µg/ml chloramphenicol for BACs. DNAs were prepared by the alkaline lysis method. 10 PAC DNAs were digested with *NotI* and subjected to pulsed-field gel electrophoresis. Sizes were determined relative to λ concatamers.

Southern blot analysis. Gel electrophoresis of 15 DNA was carried out on 0.8% agarose gels in 1x TBE. Transfer of nucleic acids to Nybond N+ nylon membrane (Amersham) was performed according to the manufacturer's instruction. Probes were labelled using RadPrime Labeling System (BRL). Hybridization was carried out at 20 42°C for 16 hours in 50% formamide, 5x SSPE, 5x Denhardt's 0.1% SDS, 100 mg/ml denatured salmon sperm DNA. The filters were washed once in 1x SSC, 0.1% SDS at room temperature for 20 minutes, and twice in 0.1x SSC, 0.1% SDS for 20 minutes at 65°C. The blots were exposed 25 onto X-ray film (Kodak, X-OMAT-AR).

Sequencing of PAC endclones. PAC clones were inoculated into 500 ml of LB/kanamycin and grown overnight. DNAs were isolated using QIAGEN columns 30 according to the vendors protocol with one additional phenol/chloroform/isoamylalcohol extraction followed by one additional chloroform/isoamylalcohol extraction. Clones were sequenced using the Gibco-BRL cycle sequencing kit with standard T7 and SP6 primers.

Hybridization of (CAG)₁₀ oligonucleotides.

Eighty ng of oligonucleotide were 5' end-labeled and hybridized overnight at 42°C in buffer containing 1 M NaCl, 0.05 M Tris HCl pH7, 5.5 mM EDTA, 0.1 % SDS, 1X 5 Denhardt's solution and 200 µg/ml denatured salmon sperm DNA. Filters were washed 2 times with 2X SSC, 0.1% SDS at 55°C and exposed to Kodak X-ray film for 24 hours, and subsequently washed at 65°C, followed by additional exposure to X-ray film.

10

Regression Analysis. The data were fit using the Statistical Analysis Software (SAS) package version 3.10 using the Secant Method (Ralston et al, 1978, *Technometrics*, 20:7-14). The regression equation was 15 $y=A \cdot \exp(-ax)$, where y gives the age of onset and x the number of CAG repeats. The conversion criteria were met with the mean square error of 76.598. The value of parameters are as follows: A=1171.583, a=0.091.

20

EXAMPLE 1

Physical Map of the SCA2 region

BAC library construction of total human genomic DNA was performed as described in Shizuya et al., *Proc. Natl. Acad. Sci. USA* 89:8794-8797 (1992). BAC clones were screened by PCR using STSs (D12S1228, S29, S32, S33). Insert size of clones was measured by running pulsed-field gel electrophoresis after digesting DNA with NotI.

30 The marker AFM128yf1 (D12S1332) which was non-recombinant in several SCA2 pedigrees served as the starting point to assemble a PAC contig. This was done by screening PCR pools of a 3x human PAC library (Ioannou et al., 1994). Two clones were positive for this STS 35 (Fig. 1). Single copy sequences from PAC ends were obtained from P168L1 and used to extend this contig.

Subsequent 'walking steps, however, were undertaken by hybridizing PCR-generated STS fragments to gridded membranes of the 3x PAC library and the 1x total human genome BAC library (Research Genetics).

5

In a similar fashion, a second contig was established starting with the telomeric flanking marker AFM154tc5 (D12S1333). A total of two clones were identified by screening of PCR pools. After several 10 walking steps, overlap of the two contigs was established by shared STSs (Fig. 1) and by shared restriction fragments (data not shown). All STSs shown in Fig. 1 were mapped back to human chromosome 12 by PCR analysis of a human/Chinese hamster somatic hybrid cell line, 15 HHW582, which contains CHR 12 as the only human chromosome, and by analysis of a chromosome 12 specific lambda library, LL12NS01 (both from Coriell Cell Repositories). Map position in 21q24.1 for clones B295C05, P191C5 and P65I22 was confirmed using FISH (Fig. 20 1b).

At the same time contigs were constructed for the other flanking markers AFM240wel (D12S1328), AFM291xe9 (D12S1329), and markers WI-4176 and WI-6850 25 (data not shown). These contigs did not overlap with one another, nor with the AFM128yf1/AFM154tc5 contig.

All PAC and BAC clones were sized by pulsed-field electrophoresis after digestion with NotI. Overlap 30 of clones was initially determined by shared STS content, and subsequently confirmed by hybridization of selected clones to Southern blots of NotI/XbaI digests of clones.

The dense localization of STSs allowed the 35 precise positioning of YACs that had been identified by screening of PCR pools of the CEPH mega-YAC library with either AFM128yf1 or AFM154tc5. The only YAC that was

positive for both AFM_a128yf1 (D12S1332) and AFM154tc5, Y884_h_11, contained an approximately 200 kb interstitial deletion. A small portion of this deletion was not covered by any of the other YAC clones.

5

EXAMPLE 2

Identification of SCA2-related trinucleotide repeats

Since we had observed marked anticipation in
10 one pedigree with SCA2, we identified clones containing
trinucleotide repeats. EcoRI digests of a minimal tiling
path of PAC clones were hybridized with a (CAG)₁₀
nucleotide, as well as other trinucleotide permutations.
Three CAG positive bands of distinct sizes were
15 identified in the contig.

PAC clone P65I22 was digested with Sau3A and
subcloned into the pBluescript SK (+) phagemid
(Stratagene). After transfection into DH5 α , bacterial
20 colonies were screened for poly-CAG containing inserts
using the methods described above. Positive clones were
sequenced using the Circum Vent cycle sequencing kit (New
England Biolabs) with end-labeled T3 and T7 primers.
However, no reliable sequence could be obtained from the
25 initial plasmid PL65I22. Therefore, this plasmid was
digested with BssHII, recloned into the pBluescript
plasmid, and CAG-positive clones sequenced with primers
corresponding to the following nucleotides of the vector
sequence (primer A: 828-848, primer B: 547-565). The
30 sequence of this plasmid, designated PL65I22B, allowed
the generation of primers SCA2-A and SCA2-B, which were
used to confirm the sequence flanking the CAG repeat.

Plasmid PL65I22B containing an extended CAG
35 repeat that appeared to be embedded into a long open
reading frame (ORF) (Figure 2; SEQ ID NO:1). Sequence
analysis of this plasmid appeared to be extremely

difficult due to the abundant presence of premature terminations (see below). The CAG repeat in PL65I22B was twice interrupted and had the following structure (CAG)₈CAA(CAG)₄CAA(CAG)₈. Four additional PAC clones and 5 one BAC clone contained the SCA2 repeat, and all clones had 22 repeats with two CAA interruptions. Analysis of the genomic DNA sequence flanking the CAG repeat suggested the presence of an open reading frame (see also Figure 6) and a potential splice site 3' of the CAG 10 repeat (vertical arrow in Figure 2).

The difficulties encountered in sequencing this region suggested that stable secondary structures might be formed in this GC-rich region. Previous analysis of 15 trinucleotide repeats predisposed to expansion had suggested that these regions are predicted to form hairpin structures. We used an up-dated version of the DNA-FOLD Program (SantaLucia et al., 1996, Biochemistry, 35:3555-3562) for secondary structure predictions.

20

Subsequent analysis of the sequence flanking the CAG repeat using the OLIGO Program indicated that it contained several palindromic sequences predicted to form hairpin loops. Despite the predicted hairpin structures 25 sufficient sequence information was generated to design primers flanking the CAG repeat for the PCR analysis of patient samples.

Example 3

30 Genomic analysis of an extended CAG SCA2 repeat

Using primer pairs SCA2-A and B, genomic DNAs from normal controls and SCA2 patients were amplified and separated by agarose gel electrophoresis. The best 35 results were obtained at an annealing temperature of 63°C with denaturation times of 90 sec.

Eighty ng each of primers SCA2-A (5'-GGG CCC CTC ACC ATG TCG-3') and SCA2-B (5'-CGG GCT TGC GGA CAT TGG-3') were added to 20 ng of human DNA with standard PCR buffer and nucleotide concentrations. After an initial denaturation at 95°C for 5 minutes, 35 cycles were repeated with denaturation at 96°C for 1.5 minutes, an annealing temperature of 63°C for 30 seconds, extension at 72°C for 1.5 minutes, and a final extension of 5 minutes at 72°C.

10

PCR products obtained by PCR amplification of genomic DNAs were separated by electrophoresis through 2% agarose gels in 1x TBE buffer at 10 V/cm. Gels were transferred to nylon membranes (MSI, Westborough, MA) using standard procedures for Southern blotting. Membranes were hybridized with a (CAG)₁₀ oligonucleotide and processed as described above.

On agarose electrophoresis, a single band of approximately 130 bp was detected in 20 normal individuals, although occasionally two closely spaced bands could be observed. In contrast, all 15 patients with SCA2 from 3 independent families showed one allele in the normal size range and a larger allele ranging from approximately 190 to 250 bp. Southern blot analysis confirmed that both alleles contained CAG repeats.

To determine the exact sizes of amplified fragments, DNAs from SCA2 patients and 50 normal individuals were amplified and PCR products separated by polyacrylamide gel electrophoresis. A common allele of 22 repeats and a less frequent allele of 23 repeats were observed on normal chromosomes (Figure 3). The allele frequencies were 0.92 for the smaller and 0.08 for the larger allele. In patients from three independent SCA2 pedigrees, however, extended alleles ranging from 36 to 52 repeats were observed (Figure 3). Once expanded to

the pathologic range, the SCA2 repeat was moderately unstable and further expansion by 2 to 9 repeat units was observed during meiosis (Figure 3). There was great variability of the age of onset for a given repeat length, especially for disease alleles with 36-40 repeats (Figure 4). Due to the heterogeneous variance of age of onset we used non-linear regression, and an exponential function was successfully fitted (see methods and Figure 4). The smallest expansion of 36 repeats was seen in two men with disease onset at ages 37 and 44. The longest expansion of 52 repeats was seen in a boy with disease onset at 9 years of age.

Sequence analysis of ten normal alleles revealed that the common normal allele with 22 repeats contained the two CAA interruptions that were also detected in plasmid PL65I22B. The less frequent normal allele with 23 repeats had lost the 5' CAA interruption, and contained an additional CAG repeat at the 5'-end of the repeat. In three expanded alleles that were isolated from SCA2 patients the CAG repeat lacked any interruptions.

To determine the frequency of mutation in the SCA2 gene in non-Portuguese patients we screened DNAs from 45 independent families with autosomal dominant SCAs. Expansion of the SCA2 repeat was detected in six families. In this set of families, SCA2 expansion was twice as common as expansion in the SCA1 gene. In addition to individuals with a 'typical' SCA phenotype, expansion of the SCA2 repeat was detected in a pedigree with a MJD phenotype and one family with SCA and marked dementia.

EXAMPLE 4

Isolation of human SCA2 cDNA

cDNA library screen: ^{32}P -labeled probes were generated by PCR amplification of plasmid P65I22B using the following primer pair: 65A3: 5'CCGGCGCTGCCAATGTCC, 65B5: 5'GTAACCGTTCGGCGCCCG. A second probe was generated using primers 65A6: 5'GGCTCCCGGCGGCTCCTT; 65B6: 5'TGCTGCTGCTGCTGGGGCTTCAG. Screening of the trisomy 21 fetal brain cDNA library and the Stratagene adult human frontal cortex cDNA Lambda Zap II library was performed using the amplification products generated from plasmid P65I22B. Phages were plated to an average density of 1×10^5 per 150 cm^2 plate. Plaque lifts of 20 plates (2×10^6 phages) were made using duplicated nylon membranes (Duralose-UV, Stratagene). Hybridization and excision were performed according to the manufacturer's protocol. Hybridized membranes were washed to a final stringency of 0.2x SSC, 0.1x SDS at 65C. The filters were exposed overnight onto X-ray film. Excised phagemids were grown overnight in 5ml LB medium containing 50 ug/ml of ampicillin.

Using PCR-generated fragments containing nucleotides 39-237 and 262 to 397 (according to the sequence shown in Figure 2) we initially screened a human adult frontal cortex library (Stratagene). Through screening of 0.8×10^6 clones, two positive clones, S1 and S2, were identified. To obtain additional clones, 2×10^6 clones of a human fetal brain library generated from a fetus with trisomy 21 (Yamakawa et al., 1995, Hum. Mol. Genet., 4:709-716) were screened using the same PCR-generated fragments. A total of 15 clones were obtained, all of which were partially sequenced to determine alignment of clones. These clones appeared to belong to a total of two classes of clones (designated F1.1 through F1.7 and F2.1 through F2.8) that contained long portions

of the 3' untranslated region and a poly-A tail (Figure 5). Both classes of clones extended 40 and 265 bp 5' of the CAG repeat in the coding region of the SCA2 gene.

5 To obtain cDNA sequence for the 5' end of the SCA2 coding region, placental poly-T selected placental mRNAs (Clontech) were transcribed with MMLV reverse transcriptase and amplified with the following primer pairs: SCA2-A30: 5'CCGCCGCTCCTCACGTGT, SCA2-A31:
10 5'ACCCCCGAGAAAGCAACC; SCA2-B30: 5'-CCGTTGCCGTTGCTACCA. The sequences for primers SCA2-A30 and A31 were obtained from genomic sequence, and are located 5' to the stop codon preceding the putative initiator methionine. The sequence for SCA2-B30 was obtained from the 5' end of
15 cDNA clones F1.1 and F1.2. The amplicons obtained by RT-PCR were directly sequenced.

The composite of the human SCA2 cDNA sequence assembled from several overlapping cDNA clones is shown
20 in Figure 6 (SEQ ID NO:2). The longest open reading frame consists of 3936 bp and ends with a TAA termination codon. The stop codon is followed by 364 bp of 3' untranslated sequence. The CAG repeat is located in the 5'end of the coding region. The putative translation
25 start site follows an in frame stop codon located 78 bp upstream. The predicted molecular weight for the SCA2 translation product is 140.1 kDa with the CAG trinucleotide repeat predicted to code for glutamine. In analogy to the SCA1 gene product, we propose the name
30 ataxin-2 for the SCA2 gene product.

The cDNA sequence was compared against the GenBank database using the FASTA sequence alignment algorithms and the TIGR database. The predicted protein
35 sequence was compared against the SwissProt database and the predicted translation products of the GenBank database. These searches revealed no significant

similarities to genes of known function except for limited homologies to the GLI-Krueppel related protein YY1 (nucleotides 45 to 586, odds against chance occurrence 6.6×10^{-7}).

5

However, significant similarities were detected with two partial cDNA transcripts in the TIGR database (THC148678, H03566, odds against chance similarity $<10^{-31}$). Complete sequence analysis of these cDNA clones (purchased from ATCC) revealed significant homologies with ataxin-2. This protein was named ataxin-2 related protein (A2RP). The region showing the most significant homology including a domain of 42 amino acids with 86% identity (codons 243-284 of the consensus sequence) is shown in Figure 7. This domain is also 100% conserved in mouse ataxin-2. Despite the significant homologies, the polyglutamine tract in ataxin-2 was replaced with an interrupted polyproline tract in the related A2RP human protein and was reduced to one glutamine in the mouse SCA2 homologue (see Figure 7).

Example 6

RT-PCR and Northern blot analysis:

25 RNA isolation and reverse transcription was carried out using well-known methods (Huynh et al., 1994, Hum. Mol. Genet., 3:1075-1079). RNAs were isolated from lymphoblastoid cell lines established from patients and unrelated spouses in the FS pedigree with SCA2 (Pulst et al., 1993, Nat. Genet., 5:8-10). Multiple tissue Northern blots were purchased from Clontech. For amplification, primers located in two exons (SCA-A and SCA-B14, see also Figure 6) were chosen so that genomic DNA was not amplified. The sequence for SCA-B14 was:
30 5' TTCTCATGTGCGGCATCAAG.
35

Using RT-PCR, it was determined that the SCA2 CAG repeat was transcribed in lymphoblastoid cell lines. In cDNAs from SCA2 patients, transcription from both the normal and the expanded allele was detected using 5 oligonucleotide primers that flank the repeat. By Northern blot analysis, the SCA2 gene was determined to be widely expressed. A strong signal corresponding to a 4.5 kb transcript was detected in all brain regions examined. This transcript was also detected in RNAs 10 isolated from heart, placenta, liver, skeletal muscle, and pancreas. Little transcript was detected in lung and no transcription was detectable in kidney. A much fainter transcript of 7.5 kb could be seen in RNAs isolated from some brain regions and in some peripheral 15 tissues.

EXAMPLE 7

Isolation of mouse SCA2 cDNA

20 To identify mouse SCA2 cDNA clones, the Stratagene Lambda ZAP newborn mouse brain cDNA library was screened with a human SCA2 cDNA clone. Six clones were identified and sequenced. A full-length mouse SCA2 cDNA is set forth in SEQ ID NO:4.

25

SUMMARY OF SEQUENCES

SEQ ID NO:1 is the genomic nucleic acid sequence set forth in Figure 2.

30

SEQ ID NO:2 is the nucleic acid sequence (and the deduced amino acid sequence) of a cDNA encoding a human-derived SCA2 protein of the present invention (also set forth in Figure 6).

35

SEQ ID NO:3 is the deduced amino acid sequence of the human-derived SCA2 protein set forth in SEQ ID NO:2.

5 SEQ ID NO:4 is the nucleic acid sequence (and the deduced amino acid sequence) of a cDNA encoding a mouse-derived SCA2 protein of the present invention.

10 SEQ ID NO:5 is the deduced amino acid sequence of the mouse-derived SCA2 protein set forth in SEQ ID NO:4.

SEQUENCE LISTING

(1) GENERAL INFORMATION:

- (i) APPLICANT: CEDARS-SINAI MEDICAL CENTER
- (ii) TITLE OF INVENTION: NUCLEIC ACID ENCODING SPINOCEREBELLAR ATAXIA-2 AND PRODUCTS RELATED THERETO

(iii) NUMBER OF SEQUENCES: 5

(iv) CORRESPONDENCE ADDRESS:

- (A) ADDRESSEE: Campbell & Flores LLP
- (B) STREET: 4370 La Jolla Village Drive, Suite 700
- (C) CITY: San Diego
- (D) STATE: California
- (E) COUNTRY: USA
- (F) ZIP: 92122

(v) COMPUTER READABLE FORM:

- (A) MEDIUM TYPE: Floppy disk
- (B) COMPUTER: IBM PC compatible
- (C) OPERATING SYSTEM: PC-DOS/MS-DOS
- (D) SOFTWARE: PatentIn Release #1.0, Version #1.25

(viii) ATTORNEY/AGENT INFORMATION:

- (A) NAME: Ramos, Robert T.
- (B) REGISTRATION NUMBER: 37,915
- (C) REFERENCE/DOCKET NUMBER: FP CE 2563

(ix) TELECOMMUNICATION INFORMATION:

- (A) TELEPHONE: (619) 535-9001
- (B) TELEFAX: (619) 535-8949

(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 516 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: both
- (D) TOPOLOGY: both

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

TTGGTAGCAA CGGAAACGGC GGCGGCGCGT TTCCGGCCCGG CTCCCGGCAG	60
TCGGCGGGCC TCCCCGCCCTTTCGTGTCG TCCTTCTCCC CCTCGCCAGC CC	120
CTCCGGCCGC GCCAACCCGC GCCTCCCCGC TCGGCGCCCG TGCGTCCCCG CCGCGTTCCG	180

GGGTCTCCTT GGCGCGCCCG GCTCCCGGCT GTCCCCGCC GGCGTGCAG CCGGTGTATG	240
GGCCCCTCAC CATGTCGCTG AAGCCCCAGC AGCAGCAGCA GCAGCAGCAG CAACAGCAGC	300
AGCAGCAACA GCAGCAGCAG CAGCAGCAGC AGCCGCCGCC CGCGGCTGCC AATGTCCGCA	360
AGCCCGGCCGG CAGCGGCCCT CTAGCGTCGC CCGCCGCCGC GCCTCGCCCG TCCTCGTCCT	420
CGGTCTCCTC GTCCCTCGGCC ACGGCTCCCT CCTCGGTGGT CGCGGCGACC TCCGGCGGCC	480
GGAGGCCCGG CCTGGGCAGG TGGGTGTCGG CACCCC	516

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 4481 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: both
- (D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(ix) FEATURE:

- (A) NAME/KEY: CDS
- (B) LOCATION: 163..4101

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

ACCCCCGAGA AAGCAACCCA GCGCGCCGCC CGCTCCTCAC GTGTCCCTCC CGGCCCCGGG	60
GCCACCTCAC GTTCTGCTTC CGTCTGACCC CTCCGACTTC CGGTAAAGAG TCCCTATCCG	120
CACCTCCGCT CCCACCCGGC GCCTCGGCCGC GCCCGCCCTC CG ATG CGC TCA GCG Met Arg Ser Ala 1	174
GCC GCA GCT CCT CGG AGT CCC GCG GTG GCC ACC GAG TCT CGC CGC TTC Ala Ala Ala Pro Arg Ser Pro Ala Val Ala Thr Glu Ser Arg Arg Phe 5 10 15 20	222
GCC GCA GCC AGG TGG CCC GGG TGG CGC TCG CTC CAG CGG CCG GCG CGG Ala Ala Ala Arg Trp Pro Gly Trp Arg Ser Leu Gln Arg Pro Ala Arg 25 30 35	270
CGG AGC GGG CGG GGC GGT GGC GCG GCC CCG GGA CCG TAT CCC TCC Arg Ser Gly Arg Gly Gly Gly Ala Ala Pro Gly Pro Tyr Pro Ser 40 45 50	318
GCC GCC CCT CCC CCG CCC GGC CCC CCT CCC TCC CGG CAG AGC Ala Ala Pro Pro Pro Pro Gly Pro Gly Pro Pro Pro Ser Arg Gln Ser 55 60 65	366

TCG CCT CCC TCC GCC TCA GAC TGT TTT GGT AGC AAC GGC AAC GGC GGC Ser Pro Pro Ser Ala Ser Asp Cys Phe Gly Ser Asn Gly Asn Gly Gly	414
70 75 80	
GGC GCG TTT CGG CCC GGC TCC CGG CGG CTC CTT GGT CTC GGC GGG CCT Gly Ala Phe Arg Pro Gly Ser Arg Arg Leu Leu Gly Leu Gly Gly Pro	462
85 90 95 100	
CCC CGC CCC TTC GTC GTC GTC CTT CTC CCC CTC GCC AGC CCG GGC GCC Pro Arg Pro Phe Val Val Val Leu Leu Pro Leu Ala Ser Pro Gly Ala	510
105 110 115	
CCT CCG GCC GCG CCA ACC CGC GCC TCC CCG CTC GGC GCC CGT GCG TCC Pro Pro Ala Ala Pro Thr Arg Ala Ser Pro Leu Gly Ala Arg Ala Ser	558
120 125 130	
CCG CCG CGT TCC GGC GTC TCC TTG GCG CGC CCG GCT CCC GGC TGT CCC Pro Pro Arg Ser Gly Val Ser Leu Ala Arg Pro Ala Pro Gly Cys Pro	606
135 140 145	
CGC CCG GCG TGC GAG CCG GTG TAT GGG CCC CTC ACC ATG TCG CTG AAG Arg Pro Ala Cys Glu Pro Val Tyr Gly Pro Leu Thr Met Ser Leu Lys	654
150 155 160	
CCC CAG CAG CAG CAG CAG CAG CAG CAA CAG CAG CAG CAG CAA CAG Pro Gln	702
165 170 175 180	
CAG CAG CAG CAG CAG CAG CCG CCG CCC GCG GCT GCC AAT GTC CGC Gln Gln Gln Gln Gln Gln Pro Pro Ala Ala Asn Val Arg	750
185 190 195	
AAG CCC GGC AGC GGC CTT CTA GCG TCG CCC GCC GCG CCT TCG Lys Pro Gly Gly Ser Gly Leu Leu Ala Ser Pro Ala Ala Pro Ser	798
200 205 210	
CCG TCC TCG TCC TCG GTC TCC TCG TCC TCG GCC ACG GCT CCC TCC TCG Pro Ser Ser Ser Val Ser Ser Ser Ala Thr Ala Pro Ser Ser	846
215 220 225	
GTG GTC GCG GCG ACC TCC GGC GGC GGG AGG CCC GGC CTG GGC AGA GGT Val Val Ala Ala Thr Ser Gly Gly Arg Pro Gly Leu Gly Arg Gly	894
230 235 240	
CGA AAC AGT AAC AAA GGA CTG CCT CAG TCT ACG ATT TCT TTT GAT GGA Arg Asn Ser Asn Lys Gly Leu Pro Gln Ser Thr Ile Ser Phe Asp Gly	942
245 250 255 260	
ATC TAT GCA AAT ATG AGG ATG GTT CAT ATA CTT ACA TCA GTT GTT GGC Ile Tyr Ala Asn Met Arg Met Val His Ile Leu Thr Ser Val Val Gly	990
265 270 275	
TCC AAA TGT GAA GTA CAA GTG AAA AAT GGA GGT ATA TAT GAA GGA GTT Ser Lys Cys Glu Val Gln Val Lys Asn Gly Gly Ile Tyr Glu Gly Val	1038
280 285 290	

TTT AAA ACT TAC AGT CCG AAG TGT GAT TTG GTA CTT GAT GCC GCA CAT Phe Lys Thr Tyr Ser Pro Lys Cys Asp Leu Val Leu Asp Ala Ala His 295 300 305	1086
GAG AAA AGT ACA GAA TCC AGT TCG GGG CCG AAA CGT GAA GAA ATA ATG Glu Lys Ser Thr Glu Ser Ser Gly Pro Lys Arg Glu Glu Ile Met 310 315 320	1134
GAG AGT ATT TTG TTC AAA TGT TCA GAC TTT GTG GTA CAG TTT AAA Glu Ser Ile Leu Phe Lys Cys Ser Asp Phe Val Val Val Gln Phe Lys 325 330 335 340	1182
GAT ATG GAC TCC AGT TAT GCA AAA AGA GAT GCT TTT ACT GAC TCT GCT Asp Met Asp Ser Ser Tyr Ala Lys Arg Asp Ala Phe Thr Asp Ser Ala 345 350 355	1230
ATC AGT GCT AAA GTG AAT GGC GAA CAC AAA GAG AAG GAC CTG GAG CCC Ile Ser Ala Lys Val Asn Gly Glu His Lys Glu Lys Asp Leu Glu Pro 360 365 370	1278
TGG GAT GCA GGT GAA CTC ACA GCC AAT GAG GAA CTT GAG GCT TTG GAA Trp Asp Ala Gly Glu Leu Thr Ala Asn Glu Glu Leu Glu Ala Leu Glu 375 380 385	1326
AAT GAC GTA TCT AAT GGA TGG GAT CCC AAT GAT ATG TTT CGA TAT AAT Asn Asp Val Ser Asn Gly Trp Asp Pro Asn Asp Met Phe Arg Tyr Asn 390 395 400	1374
GAA GAA AAT TAT GGT GTA GTG TCT ACG TAT GAT AGC AGT TTA TCT TCG Glu Glu Asn Tyr Gly Val Val Ser Thr Tyr Asp Ser Ser Leu Ser Ser 405 410 415 420	1422
TAT ACA GTG CCC TTA GAA AGA GAT AAC TCA GAA GAA TTT TTA AAA CGG Tyr Thr Val Pro Leu Glu Arg Asp Asn Ser Glu Glu Phe Leu Lys Arg 425 430 435	1470
GAA GCA AGG GCA AAC CAG TTA GCA GAA GAA ATT GAG TCA AGT GCC CAG Glu Ala Arg Ala Asn Gln Leu Ala Glu Glu Ile Glu Ser Ser Ala Gln 440 445 450	1518
TAC AAA GCT CGA GTG GCC CTG GAA AAT GAT GAT AGG AGT GAG GAA GAA Tyr Lys Ala Arg Val Ala Leu Glu Asn Asp Asp Arg Ser Glu Glu Glu 455 460 465	1566
AAA TAC ACA GCA GTT CAG AGA AAT TCC AGT GAA CGT GAG GGG CAC AGC Lys Tyr Thr Ala Val Gln Arg Asn Ser Ser Glu Arg Glu Gly His Ser 470 475 480	1614
ATA AAC ACT AGG GAA AAT AAA TAT ATT CCT CCT GGA CAA AGA AAT AGA Ile Asn Thr Arg Glu Asn Lys Tyr Ile Pro Pro Gly Gln Arg Asn Arg 485 490 495 500	1662
GAA GTC ATA TCC TGG GGA AGT GGG AGA CAG AAT TCA CCG CGT ATG GGC Glu Val Ile Ser Trp Gly Ser Gly Arg Gln Asn Ser Pro Arg Met Gly 505 510 515	1710

CAG CCT GGA TCG GGC TCC ATG CCA TCA AGA TCC ACT TCT CAC ACT TCA Gln Pro Gly Ser Gly Ser Met Pro Ser Arg Ser Thr Ser His Thr Ser 520 525 530	1758
GAT TTC AAC CCG AAT TCT GGT TCA GAC CAA AGA GTA GTT AAT GGA GGT Asp Phe Asn Pro Asn Ser Gly Ser Asp Gln Arg Val Val Asn Gly Gly 535 540 545	1806
GTT CCC TGG CCA TCG CCT TGC CCA TCT CCT TCC TCT CGC CCA CCT TCT Val Pro Trp Pro Ser Pro Cys Pro Ser Pro Ser Arg Pro Pro Ser 550 555 560	1854
CGC TAC CAG TCA GGT CCC AAC TCT CTT CCA CCT CGG GCA GCC ACC CCT Arg Tyr Gln Ser Gly Pro Asn Ser Leu Pro Pro Arg Ala Ala Thr Pro 565 570 575 580	1902
ACA CGG CCG CCC TCC AGG CCC CCC TCG CGG CCA TCC AGA CCC CCG TCT Thr Arg Pro Pro Ser Arg Pro Ser Arg Pro Ser Arg Pro Pro Ser 585 590 595	1950
CAC CCC TCT GCT CAT GGT TCT CCA GCT CCT GTC TCT ACT ATG CCT AAA His Pro Ser Ala His Gly Ser Pro Ala Pro Val Ser Thr Met Pro Lys 600 605 610	1998
CGC ATG TCT TCA GAA GGG CCT CCA AGG ATG TCC CCA AAG GCC CAG CGA Arg Met Ser Ser Glu Gly Pro Pro Arg Met Ser Pro Lys Ala Gln Arg 615 620 625	2046
CAT CCT CGA AAT CAC AGA GTT TCT GCT GGG AGG GGT TCC ATA TCC AGT His Pro Arg Asn His Arg Val Ser Ala Gly Arg Gly Ser Ile Ser Ser 630 635 640	2094
GGC CTA GAA TTT GTA TCC CAC AAC CCA CCC AGT GAA GCA GCT ACT CCT Gly Leu Glu Phe Val Ser His Asn Pro Pro Ser Glu Ala Ala Thr Pro 645 650 655 660	2142
CCA GTA GCA AGG ACC AGT CCC TCG GGG GGA ACG TGG TCA TCA GTG GTC Pro Val Ala Arg Thr Ser Pro Ser Gly Gly Thr Trp Ser Ser Val Val 665 670 675	2190
AGT GGG GTT CCA AGA TTA TCC CCT AAA ACT CAT AGA CCC AGG TCT CCC Ser Gly Val Pro Arg Leu Ser Pro Lys Thr His Arg Pro Arg Ser Pro 680 685 690	2238
AGA CAG AAC AGT ATT GGA AAT ACC CCC AGT GGG CCA GTT CTT GCT TCT Arg Gln Asn Ser Ile Gly Asn Thr Pro Ser Gly Pro Val Leu Ala Ser 695 700 705	2286
CCC CAA GCT GGT ATT ATT CCA ACT GAA GCT GTT GCC ATG CCT ATT CCA Pro Gln Ala Gly Ile Ile Pro Thr Glu Ala Val Ala Met Pro Ile Pro 710 715 720	2334
GCT GCA TCT CCT ACG CCT GCT AGT CCT GCA TCG AAC AGA GCT GTT ACC Ala Ala Ser Pro Thr Pro Ala Ser Pro Ala Ser Asn Arg Ala Val Thr 725 730 735 740	2382

CCT TCT AGT GAG GCT AAA GAT TCC AGG CTT CAA GAT CAG AGG CAG AAC Pro Ser Ser Glu Ala Lys Asp Ser Arg Leu Gln Asp Gln Arg Gln Asn 745 750 755	2430
TCT CCT GCA GGG AAT AAA GAA AAT ATT AAA CCC AAT GAA ACA TCA CCT Ser Pro Ala Gly Asn Lys Glu Asn Ile Lys Pro Asn Glu Thr Ser Pro 760 765 770	2478
AGC TTC TCA AAA GCT GAA AAC AAA GGT ATA TCA CCA GTT GTT TCT GAA Ser Phe Ser Lys Ala Glu Asn Lys Gly Ile Ser Pro Val Val Ser Glu 775 780 785	2526
CAT AGA AAA CAG ATT GAT GAT TTA AAG AAA TTT AAG AAT GAT TTT AGG His Arg Lys Gln Ile Asp Asp Leu Lys Lys Phe Lys Asn Asp Phe Arg 790 795 800	2574
TTA CAG CCA AGT TCT ACT TCT GAA TCT ATG GAT CAA CTA CTA AAC AAA Leu Gln Pro Ser Ser Thr Ser Glu Ser Met Asp Gln Leu Leu Asn Lys 805 810 815 820	2622
AAT AGA GAG GGA GAA AAA TCA AGA GAT TTG ATC AAA GAC AAA ATT GAA Asn Arg Glu Gly Lys Ser Arg Asp Leu Ile Lys Asp Lys Ile Glu 825 830 835	2670
CCA AGT GCT AAG GAT TCT TTC ATT GAA AAT AGC AGC AGC AAC TGT ACC Pro Ser Ala Lys Asp Ser Phe Ile Glu Asn Ser Ser Asn Cys Thr 840 845 850	2718
AGT GGC AGC AGC AAG CCG AAT AGC CCC AGC ATT TCC CCT TCA ATA CTT Ser Gly Ser Ser Lys Pro Asn Ser Pro Ser Ile Ser Pro Ser Ile Leu 855 860 865	2766
AGT AAC ACG GAG CAC AAG AGG GGA CCT GAG GTC ACT TCC CAA GGG GTT Ser Asn Thr Glu His Lys Arg Gly Pro Glu Val Thr Ser Gln Gly Val 870 875 880	2814
CAG ACT TCC AGC CCA GCA TGT AAA CAA GAG AAA GAC GAT AAG GAA GAG Gln Thr Ser Ser Pro Ala Cys Lys Gln Glu Lys Asp Asp Lys Glu Glu 885 890 895 900	2862
AAG AAA GAC GCA GCT GAG CAA GTT AGG AAA TCA ACA TTG AAT CCC AAT Lys Lys Asp Ala Ala Glu Gln Val Arg Lys Ser Thr Leu Asn Pro Asn 905 910 915	2910
GCA AAG GAG TTC AAC CCA CGT TCC TTC TCT CAG CCA AAG CCT TCT ACT Ala Lys Glu Phe Asn Pro Arg Ser Phe Ser Gln Pro Lys Pro Ser Thr 920 925 930	2958
ACC CCA ACT TCA CCT CGG CCT CAA GCA CAA CCT AGC CCA TCT ATG GTG Thr Pro Thr Ser Pro Arg Pro Gln Ala Gln Pro Ser Pro Ser Met Val 935 940 945	3006
GGT CAT CAA CAG CCA ACT CCA GTT TAT ACT CAG CCT GTT TGT TTT GCA Gly His Gln Gln Pro Thr Pro Val Tyr Thr Gln Pro Val Cys Phe Ala 950 955 960	3054

CCA AAT ATG ATG TAT CCA GTC CCA GTG AGC CCA GGC GTG CAA CCT TTA Pro Asn Met Met Tyr Pro Val Pro Val Ser Pro Gly Val Gln Pro Leu 965 970 975 980	3102
TAC CCA ATA CCT ATG ACG CCC ATG CCA GTG AAT CAA GCC AAG ACA TAT Tyr Pro Ile Pro Met Thr Pro Met Pro Val Asn Gln Ala Lys Thr Tyr 985 990 995	3150
AGA GCA GTA CCA AAT ATG CCC CAA CAG CGG CAA GAC CAG CAT CAT CAG Arg Ala Val Pro Asn Met Pro Gln Gln Arg Gln Asp Gln His His Gln 1000 1005 1010	3198
AGT GCC ATG ATG CAC CCA GCG TCA GCA GCG GGC CCA CCG ATT GCA GCC Ser Ala Met Met His Pro Ala Ser Ala Ala Gly Pro Pro Ile Ala Ala 1015 1020 1025	3246
ACC CCA CCA GCT TAC TCC ACG CAA TAT GTT GCC TAC AGT CCT CAG CAG Thr Pro Pro Ala Tyr Ser Thr Gln Tyr Val Ala Tyr Ser Pro Gln Gln 1030 1035 1040	3294
TTC CCA AAT CAG CCC CTT GTT CAG CAT GTG CCA CAT TAT CAG TCT CAG Phe Pro Asn Gln Pro Leu Val Gln His Val Pro His Tyr Gln Ser Gln 1045 1050 1055 1060	3342
CAT CCT CAT GTC TAT AGT CCT GTA ATA CAG GGT AAT GCT AGA ATG ATG His Pro His Val Tyr Ser Pro Val Ile Gln Gly Asn Ala Arg Met Met 1065 1070 1075	3390
GCA CCA CCA ACA CAC GCC CAG CCT GGT TTA GTA TCT TCT TCA GCA ACT Ala Pro Pro Thr His Ala Gln Pro Gly Leu Val Ser Ser Ala Thr 1080 1085 1090	3438
CAG TAC GGG GCT CAT GAG CAG ACG CAT GCG ATG TAT GCA TGT CCC AAA Gln Tyr Gly Ala His Glu Gln Thr His Ala Met Tyr Ala Cys Pro Lys 1095 1100 1105	3486
TTA CCA TAC AAC AAG GAG ACA AGC CCT TCT TTC TAC TTT GCC ATT TCC Leu Pro Tyr Asn Lys Glu Thr Ser Pro Ser Phe Tyr Phe Ala Ile Ser 1110 1115 1120	3534
ACG GGC TCC CTT GCT CAG CAG TAT GCG CAC CCT AAC GCT ACC CTG CAC Thr Gly Ser Leu Ala Gln Gln Tyr Ala His Pro Asn Ala Thr Leu His 1125 1130 1135 1140	3582
CCA CAT ACT CCA CAC CCT CAG CCT TCA GCT ACC CCC ACT GGA CAG CAG Pro His Thr Pro His Pro Gln Pro Ser Ala Thr Pro Thr Gly Gln Gln 1145 1150 1155	3630
CAA AGC CAA CAT GGT GGA AGT CAT CCT GCA CCC AGT CCT GTT CAG CAC Gln Ser Gln His Gly Gly Ser His Pro Ala Pro Ser Pro Val Gln His 1160 1165 1170	3678
CAT CAG CAC CAG GCC CAG GCT CTC CAT CTG GCC AGT CCA CAG CAG His Gln His Gln Ala Ala Gln Ala Leu His Leu Ala Ser Pro Gln Gln 1175 1180 1185	3726

CAG TCA GCC ATT TAC CAC GCG GGG CTT GCG CCA ACT CCA CCC TCC ATG Gln Ser Ala Ile Tyr His Ala Gly Leu Ala Pro Thr Pro Pro Ser Met 1190 1195 1200	3774
ACA CCT GCC TCC AAC ACG CAG TCG CCA CAG AAT AGT TTC CCA GCA GCA Thr Pro Ala Ser Asn Thr Gln Ser Pro Gln Asn Ser Phe Pro Ala Ala 1205 1210 1215 1220	3822
CAA CAG ACT GTC TTT ACG ATC CAT CCT TCT CAC GTT CAG CCG GCG TAT Gln Gln Thr Val Phe Thr Ile His Pro Ser His Val Gln Pro Ala Tyr 1225 1230 1235	3870
ACC AAC CCA CCC CAC ATG GCC CAC GTA CCT CAG GCT CAT GTA CAG TCA Thr Asn Pro Pro His Met Ala His Val Pro Gln Ala His Val Gln Ser 1240 1245 1250	3918
GGA ATG GTT CCT TCT CAT CCA ACT GCC CAT GCG CCA ATG ATG CTA ATG Gly Met Val Pro Ser His Pro Thr Ala His Ala Pro Met Met Leu Met 1255 1260 1265	3966
ACG ACA CAG CCA CCC GGC GGT CCC CAG GCC CTC GCT CAA AGT GCA Thr Thr Gln Pro Pro Gly Gly Pro Gln Ala Ala Leu Ala Gln Ser Ala 1270 1275 1280	4014
CTA CAG CCC ATT CCA GTC TCG ACA ACA GCG CAT TTC CCC TAT ATG ACG Leu Gln Pro Ile Pro Val Ser Thr Thr Ala His Phe Pro Tyr Met Thr 1285 1290 1295 1300	4062
CAC CCT TCA GTA CAA GCC CAC CAC CAA CAG CAG TTG TAAGGCTGCC His Pro Ser Val Gln Ala His His Gln Gln Gln Leu 1305 1310	4108
CTGGAGGAAC CGAAAGGCCA AATTCCCTCC TCCCTTCTAC TGCTTCTACC AACTGGAAGC ACAGAAAACT AGAATTCAT TTATTTGTT TTTAAAATAT ATATGTTGAT TTCTTGTAAC ATCCAATAGG AATGCTAACCA GTTCACTTGC AGTGGAAAGAT ACTTGGACCG AGTAGAGGCCA TTTAGGAACT TGGGGCTAT TCCATAATTC CATATGCTGT TTCAGAGTCC CGCAGGTACC CCAGCTCTGC TTGCCGAAAC TGGAAAGTTAT TTATTTTTA ATAACCCTTG AAAGTCATGA ACACATCAGC TAGCAAAAGA AGTAACAAGA GTGATTCTTG CTGCTATTAC TGCTAAAAAA AAAAAAAAAAA AAA	4168 4228 4288 4348 4408 4468 4481

(2) INFORMATION FOR SEQ ID NO:3:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 1312 amino acids
 - (B) TYPE: amino acid
 - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

Met Arg Ser Ala Ala Ala Ala Pro Arg Ser Pro Ala Val Ala Thr Glu
1 5 10 15

Ser Arg Arg Phe Ala Ala Ala Arg Trp Pro Gly Trp Arg Ser Leu Gln
20 25 30

Arg Pro Ala Arg Arg Ser Gly Arg Gly Gly Gly Ala Ala Pro Gly
35 40 45

Pro Tyr Pro Ser Ala Ala Pro Pro Pro Gly Pro Gly Pro Pro Pro
50 55 60

Ser Arg Gln Ser Ser Pro Pro Ser Ala Ser Asp Cys Phe Gly Ser Asn
65 70 75 80

Gly Asn Gly Gly Gly Ala Phe Arg Pro Gly Ser Arg Arg Leu Leu Gly
85 90 95

Leu Gly Gly Pro Pro Arg Pro Phe Val Val Val Leu Leu Pro Leu Ala
100 105 110

Ser Pro Gly Ala Pro Pro Ala Ala Pro Thr Arg Ala Ser Pro Leu Gly
115 120 125

Ala Arg Ala Ser Pro Pro Arg Ser Gly Val Ser Leu Ala Arg Pro Ala
130 135 140

Pro Gly Cys Pro Arg Pro Ala Cys Glu Pro Val Tyr Gly Pro Leu Thr
145 150 155 160

Met Ser Leu Lys Pro Gln
165 170 175

Gln Gln Gln Gln Gln Gln Gln Gln Gln Pro Pro Pro Ala Ala
180 185 190

Ala Asn Val Arg Lys Pro Gly Gly Ser Gly Leu Leu Ala Ser Pro Ala
195 200 205

Ala Ala Pro Ser Pro Ser Ser Ser Val Ser Ser Ser Ala Thr
210 215 220

Ala Pro Ser Ser Val Val Ala Ala Thr Ser Gly Gly Gly Arg Pro Gly
225 230 235 240

Leu Gly Arg Gly Arg Asn Ser Asn Lys Gly Leu Pro Gln Ser Thr Ile
245 250 255

Ser Phe Asp Gly Ile Tyr Ala Asn Met Arg Met Val His Ile Leu Thr
260 265 270

Ser Val Val Gly Ser Lys Cys Glu Val Gln Val Lys Asn Gly Gly Ile
275 280 285

Tyr Glu Gly Val Phe Lys Thr Tyr Ser Pro Lys Cys Asp Leu Val Leu
 290 295 300
 Asp Ala Ala His Glu Lys Ser Thr Glu Ser Ser Ser Gly Pro Lys Arg
 305 310 315 320
 Glu Glu Ile Met Glu Ser Ile Leu Phe Lys Cys Ser Asp Phe Val Val
 325 330 335
 Val Gln Phe Lys Asp Met Asp Ser Ser Tyr Ala Lys Arg Asp Ala Phe
 340 345 350
 Thr Asp Ser Ala Ile Ser Ala Lys Val Asn Gly Glu His Lys Glu Lys
 355 360 365
 Asp Leu Glu Pro Trp Asp Ala Gly Glu Leu Thr Ala Asn Glu Glu Leu
 370 375 380
 Glu Ala Leu Glu Asn Asp Val Ser Asn Gly Trp Asp Pro Asn Asp Met
 385 390 395 400
 Phe Arg Tyr Asn Glu Glu Asn Tyr Gly Val Val Ser Thr Tyr Asp Ser
 405 410 415
 Ser Leu Ser Ser Tyr Thr Val Pro Leu Glu Arg Asp Asn Ser Glu Glu
 420 425 430
 Phe Leu Lys Arg Glu Ala Arg Ala Asn Gln Leu Ala Glu Glu Ile Glu
 435 440 445
 Ser Ser Ala Gln Tyr Lys Ala Arg Val Ala Leu Glu Asn Asp Asp Arg
 450 455 460
 Ser Glu Glu Glu Lys Tyr Thr Ala Val Gln Arg Asn Ser Ser Glu Arg
 465 470 475 480
 Glu Gly His Ser Ile Asn Thr Arg Glu Asn Lys Tyr Ile Pro Pro Gly
 485 490 495
 Gln Arg Asn Arg Glu Val Ile Ser Trp Gly Ser Gly Arg Gln Asn Ser
 500 505 510
 Pro Arg Met Gly Gln Pro Gly Ser Gly Ser Met Pro Ser Arg Ser Thr
 515 520 525
 Ser His Thr Ser Asp Phe Asn Pro Asn Ser Gly Ser Asp Gln Arg Val
 530 535 540
 Val Asn Gly Gly Val Pro Trp Pro Ser Pro Cys Pro Ser Pro Ser Ser
 545 550 555 560
 Arg Pro Pro Ser Arg Tyr Gln Ser Gly Pro Asn Ser Leu Pro Pro Arg
 565 570 575

Ala Ala Thr Pro Thr Arg Pro Pro Ser Arg Pro Pro Ser Arg Pro Ser
580 585 590

Arg Pro Pro Ser His Pro Ser Ala His Gly Ser Pro Ala Pro Val Ser
595 600 605

Thr Met Pro Lys Arg Met Ser Ser Glu Gly Pro Pro Arg Met Ser Pro
610 615 620

Lys Ala Gln Arg His Pro Arg Asn His Arg Val Ser Ala Gly Arg Gly
625 630 635 640

Ser Ile Ser Ser Gly Leu Glu Phe Val Ser His Asn Pro Pro Ser Glu
645 650 655

Ala Ala Thr Pro Pro Val Ala Arg Thr Ser Pro Ser Gly Gly Thr Trp
660 665 670

Ser Ser Val Val Ser Gly Val Pro Arg Leu Ser Pro Lys Thr His Arg
675 680 685

Pro Arg Ser Pro Arg Gln Asn Ser Ile Gly Asn Thr Pro Ser Gly Pro
690 695 700

Val Leu Ala Ser Pro Gln Ala Gly Ile Ile Pro Thr Glu Ala Val Ala
705 710 715 720

Met Pro Ile Pro Ala Ala Ser Pro Thr Pro Ala Ser Pro Ala Ser Asn
725 730 735

Arg Ala Val Thr Pro Ser Ser Glu Ala Lys Asp Ser Arg Leu Gln Asp
740 745 750

Gln Arg Gln Asn Ser Pro Ala Gly Asn Lys Glu Asn Ile Lys Pro Asn
755 760 765

Glu Thr Ser Pro Ser Phe Ser Lys Ala Glu Asn Lys Gly Ile Ser Pro
770 775 780

Val Val Ser Glu His Arg Lys Gln Ile Asp Asp Leu Lys Lys Phe Lys
785 790 795 800

Asn Asp Phe Arg Leu Gln Pro Ser Ser Thr Ser Glu Ser Met Asp Gln
805 810 815

Leu Leu Asn Lys Asn Arg Glu Gly Glu Lys Ser Arg Asp Leu Ile Lys
820 825 830

Asp Lys Ile Glu Pro Ser Ala Lys Asp Ser Phe Ile Glu Asn Ser Ser
835 840 845

Ser Asn Cys Thr Ser Gly Ser Ser Lys Pro Asn Ser Pro Ser Ile Ser
850 855 860

Pro Ser Ile Leu Ser Asn Thr Glu His Lys Arg Gly Pro Glu Val Thr
865 870 875 880

Ser Gln Gly Val Gln Thr Ser Ser Pro Ala Cys Lys Gln Glu Lys Asp
885 890 895

Asp Lys Glu Glu Lys Lys Asp Ala Ala Glu Gln Val Arg Lys Ser Thr
900 905 910

Leu Asn Pro Asn Ala Lys Glu Phe Asn Pro Arg Ser Phe Ser Gln Pro
915 920 925

Lys Pro Ser Thr Thr Pro Thr Ser Pro Arg Pro Gln Ala Gln Pro Ser
930 935 940

Pro Ser Met Val Gly His Gln Gln Pro Thr Pro Val Tyr Thr Gln Pro
945 950 955 960

Val Cys Phe Ala Pro Asn Met Met Tyr Pro Val Pro Val Ser Pro Gly
965 970 975

Val Gln Pro Leu Tyr Pro Ile Pro Met Thr Pro Met Pro Val Asn Gln
980 985 990

Ala Lys Thr Tyr Arg Ala Val Pro Asn Met Pro Gln Gln Arg Gln Asp
995 1000 1005

Gln His His Gln Ser Ala Met Met His Pro Ala Ser Ala Ala Gly Pro
1010 1015 1020

Pro Ile Ala Ala Thr Pro Pro Ala Tyr Ser Thr Gln Tyr Val Ala Tyr
1025 1030 1035 1040

Ser Pro Gln Gln Phe Pro Asn Gln Pro Leu Val Gln His Val Pro His
1045 1050 1055

Tyr Gln Ser Gln His Pro His Val Tyr Ser Pro Val Ile Gln Gly Asn
1060 1065 1070

Ala Arg Met Met Ala Pro Pro Thr His Ala Gln Pro Gly Leu Val Ser
1075 1080 1085

Ser Ser Ala Thr Gln Tyr Gly Ala His Glu Gln Thr His Ala Met Tyr
1090 1095 1100

Ala Cys Pro Lys Leu Pro Tyr Asn Lys Glu Thr Ser Pro Ser Phe Tyr
1105 1110 1115 1120

Phe Ala Ile Ser Thr Gly Ser Leu Ala Gln Gln Tyr Ala His Pro Asn
1125 1130 1135

Ala Thr Leu His Pro His Thr Pro His Pro Gln Pro Ser Ala Thr Pro
1140 1145 1150

Thr Gly Gln Gln Gln Ser Gln His Gly Gly Ser His Pro Ala Pro Ser
 1155 1160 1165
 Pro Val Gln His His Gln His Gln Ala Ala Gln Ala Leu His Leu Ala
 1170 1175 1180
 Ser Pro Gln Gln Gln Ser Ala Ile Tyr His Ala Gly Leu Ala Pro Thr
 1185 1190 1195 1200
 Pro Pro Ser Met Thr Pro Ala Ser Asn Thr Gln Ser Pro Gln Asn Ser
 1205 1210 1215
 Phe Pro Ala Ala Gln Gln Thr Val Phe Thr Ile His Pro Ser His Val
 1220 1225 1230
 Gln Pro Ala Tyr Thr Asn Pro Pro His Met Ala His Val Pro Gln Ala
 1235 1240 1245
 His Val Gln Ser Gly Met Val Pro Ser His Pro Thr Ala His Ala Pro
 1250 1255 1260
 Met Met Leu Met Thr Thr Gln Pro Pro Gly Gly Pro Gln Ala Ala Leu
 1265 1270 1275 1280
 Ala Gln Ser Ala Leu Gln Pro Ile Pro Val Ser Thr Thr Ala His Phe
 1285 1290 1295
 Pro Tyr Met Thr His Pro Ser Val Gln Ala His His Gln Gln Leu
 1300 1305 1310

(2) INFORMATION FOR SEQ ID NO:4:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 3798 base pairs
 - (B) TYPE: nucleic acid
 - (C) STRANDEDNESS: both
 - (D) TOPOLOGY: both

- (ix) FEATURE:
 - (A) NAME/KEY: CDS
 - (B) LOCATION: 50..3457

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

GGCACGAGGT CCCCCGCCGG CGTGCGAGCC GGTGTATGGG CCGCTCAC₁ ATG TCG
 Met Ser

55

CTG AAG CCG CAG CCG CAG CCC GCG CCC GCC ACT GGC CGC AAG CCC Leu Lys Pro Gln Pro Gln Pro Ala Pro Ala Thr Gly Arg Lys Pro	103
5 10 15	
GGC GGC GGC CTG CTC TCG TCG CCC GGC GCC GCG CCG GCC TCG GCC GCG Gly Gly Leu Leu Ser Ser Pro Gly Ala Ala Pro Ala Ser Ala Ala	151
20 25 30	
GTG ACC TCG GCT TCC GTG GTG CCG GCC CCG GCG CCG GTG GCG TCT Val Thr Ser Ala Ser Val Val Pro Ala Pro Ala Ala Pro Val Ala Ser	199
35 40 45 50	
TCC TCG GCG GCC GCG GGC GGC GGG CGT CCC GGC CTG GGC AGA GGT CGG Ser Ser Ala Ala Gly Gly Arg Pro Gly Leu Gly Arg Gly Arg	247
55 60 65	
AAC AGT AGC AAA GGA CTG CCT CAG CCT ACG ATT TCT TTT GAT GGA ATC Asn Ser Ser Lys Gly Leu Pro Gln Pro Thr Ile Ser Phe Asp Gly Ile	295
70 75 80	
TAT GCA AAC GTG AGG ATG GTT CAT ATA CTT ACG TCA GTT GTT GGA TCG Tyr Ala Asn Val Arg Met Val His Ile Leu Thr Ser Val Val Gly Ser	343
85 90 95	
AAA TGT GAA GTA CAA GTG AAA AAC GGA GGC ATA TAT GAA GGA GTT TTT Lys Cys Glu Val Gln Val Lys Asn Gly Gly Ile Tyr Glu Gly Val Phe	391
100 105 110	
AAA ACA TAC AGT CCT AAG TGT GAC TTG GTA CTT GAT GCT GCA CAT GAG Lys Thr Tyr Ser Pro Lys Cys Asp Leu Val Leu Asp Ala Ala His Glu	439
115 120 125 130	
AAA AGT ACA GAA TCC AGT TCG GGG CCA AAA CGT GAA GAA ATA ATG GAG Lys Ser Thr Glu Ser Ser Gly Pro Lys Arg Glu Glu Ile Met Glu	487
135 140 145	
AGT GTT TTG TTC AAA TGC TCA GAC TTC GTT GTG GTA CAG TTT AAA GAT Ser Val Leu Phe Lys Cys Ser Asp Phe Val Val Val Gln Phe Lys Asp	535
150 155 160	
ACA GAC TCC AGT TAT GCA CGG AGA GAT GCT TTT ACT GAC TCT GCT CTC Thr Asp Ser Ser Tyr Ala Arg Arg Asp Ala Phe Thr Asp Ser Ala Leu	583
165 170 175	
AGC GCA AAG GTG AAT GGT GAG CAC AAG GAG AAG GAC CTG GAG CCC TGG Ser Ala Lys Val Asn Gly Glu His Lys Glu Lys Asp Leu Glu Pro Trp	631
180 185 190	
GAT GCA GGG GAG CTC ACG GCC AGC GAG GAG CTG GAG CTG GAG AAT GAT Asp Ala Gly Glu Leu Thr Ala Ser Glu Glu Leu Glu Leu Glu Asn Asp	679
195 200 205 210	
GTG TCT AAT GGA TGG GAC CCC AAT GAC ATG TTT CGA TAT AAT GAA GAG Val Ser Asn Gly Trp Asp Pro Asn Asp Met Phe Arg Tyr Asn Glu Glu	727
215 220 225	

AAT TAT GGT GTG GTG TCC ACA TAT GAT AGC AGT TTA TCT TCA TAT ACG Asn Tyr Gly Val Val Ser Thr Tyr Asp Ser Ser Leu Ser Ser Tyr Thr 230 235 240	775
GTT CCT TTA GAA AGG GAC AAC TCA GAA GAA TTT CTT AAA CGG GAG GCA Val Pro Leu Glu Arg Asp Asn Ser Glu Glu Phe Leu Lys Arg Glu Ala 245 250 255	823
AGG GCA AAC CAG TTA GCA GAA GAA ATT GAA TCC AGT GCT CAG TAC AAA Arg Ala Asn Gln Leu Ala Glu Glu Ile Glu Ser Ser Ala Gln Tyr Lys 260 265 270	871
GCT CGT GTC GCC CTT GAG AAT GAT GAC CGG AGT GAG GAA GAA AAA TAC Ala Arg Val Ala Leu Glu Asn Asp Asp Arg Ser Glu Glu Glu Lys Tyr 275 280 285 290	919
ACA GCA GTC CAG AGA AAC TGC AGT GAC CGG GAG GGG CAT GGC CCC AAC Thr Ala Val Gln Arg Asn Cys Ser Asp Arg Glu Gly His Gly Pro Asn 295 300 305	967
ACT AGG GAC AAT AAA TAT ATT CCT CCT GGA CAA AGA AAC AGA GAA GTC Thr Arg Asp Asn Lys Tyr Ile Pro Pro Gly Gln Arg Asn Arg Glu Val 310 315 320	1015
CTA TCC TGG GGA AGT GGG AGA CAG AGC TCA CCA CGG ATG GGC CAG CCT Leu Ser Trp Gly Ser Gly Arg Gln Ser Ser Pro Arg Met Gly Gln Pro 325 330 335	1063
GGG CCA GGC TCC ATG CCG TCA AGA GCT GCT TCT CAC ACT TCA GAT TTC Gly Pro Gly Ser Met Pro Ser Arg Ala Ala Ser His Thr Ser Asp Phe 340 345 350	1111
AAC CCG AAC GCT GGC TCA GAC CAA AGA GTA GTT AAT GGA GGT GTT CCC Asn Pro Asn Ala Gly Ser Asp Gln Arg Val Val Asn Gly Gly Val Pro 355 360 365 370	1159
TGG CCA TCG CCT TGC CCA TCT CAT TCC TCT CGC CCA CCT TCT CGC TAC Trp Pro Ser Pro Cys Pro Ser His Ser Ser Arg Pro Pro Ser Arg Tyr 375 380 385	1207
CAG TCA GGT CCC AAC TCT CTT CCA CCT CGG GCA GCC ACC CAT ACA CGG Gln Ser Gly Pro Asn Ser Leu Pro Pro Arg Ala Ala Thr His Thr Arg 390 395 400	1255
CCG CCC TCC AGG CCC CCC TCG AGG CCA TCC AGA CCC CCG TCT CAC CCC Pro Pro Ser Arg Pro Pro Ser Arg Pro Ser Arg Pro Pro Ser His Pro 405 410 415	1303
TCT GCT CAT GGT TCT CCA GCT CCT GTC TCT ACT ATG CCT AAA CGC ATG Ser Ala His Gly Ser Pro Ala Pro Val Ser Thr Met Pro Lys Arg Met 420 425 430	1351
TCT TCA GAA GGA CCC CCA AGG ATG TCT CCA AAG GCA CAG CGC CAC CCT Ser Ser Glu Gly Pro Pro Arg Met Ser Pro Lys Ala Gln Arg His Pro 435 440 445 450	1399

CGG AAT CAC AGA GTC TCT GCT GGG AGA GGC TCC ATG TCT AGT GGC CTA Arg Asn His Arg Val Ser Ala Gly Arg Gly Ser Met Ser Ser Gly Leu 455 460 465	1447
GAA TTT GTA TCC CAC AAT CCC CCA AGT GAA GCA GCT GCT CCT CCA GTG Glu Phe Val Ser His Asn Pro Pro Ser Glu Ala Ala Ala Pro Pro Val 470 475 480	1495
GCA AGG ACC AGT CCT GCA GGG GGA ACG TGG TCC TCA GTG GTC AGT GGG Ala Arg Thr Ser Pro Ala Gly Gly Thr Trp Ser Ser Val Val Ser Gly 485 490 495	1543
GTT CCA AGG TTA TCT CCC AAA ACT CAC AGA CCC AGG TCT CCC AGG CAG Val Pro Arg Leu Ser Pro Lys Thr His Arg Pro Arg Ser Pro Arg Gln 500 505 510	1591
AGC AGC ATT GGA AAC TCT CCC AGC GGG CCT GTG CTT GCT TCT CCC CAA Ser Ser Ile Gly Asn Ser Pro Ser Gly Pro Val Leu Ala Ser Pro Gln 515 520 525 530	1639
GCT GGC ATC ATC CCT GCA GAA GCC GTT TCC ATG CCT GTT CCC GCC GCA Ala Gly Ile Ile Pro Ala Glu Ala Val Ser Met Pro Val Pro Ala Ala 535 540 545	1687
TCT CCG ACT CCT GCC AGC CCT GCA TCC AAC AGA GCA CTG ACC CCA TCT Ser Pro Thr Pro Ala Ser Pro Ala Ser Asn Arg Ala Leu Thr Pro Ser 550 555 560	1735
ATT GAG GCA AAA GAT TCC AGG CTT CAA GAT CAG AGG CAG AAC TCT CCT Ile Glu Ala Lys Asp Ser Arg Leu Gln Asp Gln Arg Gln Asn Ser Pro 565 570 575	1783
GCA GGG AGT AAA GAA AAT GTT AAA GCA AGT GAA ACA TCA CCT AGC TTT Ala Gly Ser Lys Glu Asn Val Lys Ala Ser Glu Thr Ser Pro Ser Phe 580 585 590	1831
TCA AAA GCT GAC AAC AAA GGT ATG TCA CCA GTT GTT TCT GAA CAC AGA Ser Lys Ala Asp Asn Lys Gly Met Ser Pro Val Val Ser Glu His Arg 595 600 605 610	1879
AAA CAG ATT GAT GAC TTA AAG AAG TTT AAG AAT GAT TTT AGG TTA CAG Lys Gln Ile Asp Asp Leu Lys Lys Phe Lys Asn Asp Phe Arg Leu Gln 615 620 625	1927
CCA AGC TCT ACA TCT GAA TCT ATG GAT CAA CTA CTA AGC AAA AAT AGA Pro Ser Ser Thr Ser Glu Ser Met Asp Gln Leu Leu Ser Lys Asn Arg 630 635 640	1975
GAA GGA GAA AAG TCA CGA GAT TTG ATT AAA GAT AAA ACG GAA GCA AGT Glu Gly Glu Lys Ser Arg Asp Leu Ile Lys Asp Lys Thr Glu Ala Ser 645 650 655	2023
GCT AAG GAT AGT TTC ATT GAC AGC AGC AGC AGC AGC AAC TGT ACC Ala Lys Asp Ser Phe Ile Asp Ser Ser Ser Ser Asn Cys Thr 660 665 670	2071

AGT GGC AGC AGC AAG ACC AAC AGC CCT AGC ATC TCC CCT TCC ATG CTT Ser Gly Ser Ser Lys Thr Asn Ser Pro Ser Ile Ser Pro Ser Met Leu 675 680 685 690	2119
AGT AAT GCA GAG CAC AAG AGG GGG CCT GAG GTC ACA TCC CAA GGG GTG Ser Asn Ala Glu His Lys Arg Gly Pro Glu Val Thr Ser Gln Gly Val 695 700 705	2167
CAG ACT TCC AGC CCA GCC TGC AAA CAA GAG AAG GAT GAC AGA GAA GAG Gln Thr Ser Ser Pro Ala Cys Lys Gln Glu Lys Asp Asp Arg Glu Glu 710 715 720	2215
AAG AAA GAC ACA ACA GAG CAG GTT AGG AAA TCG ACA TTG AAT CCC AAT Lys Lys Asp Thr Thr Glu Gln Val Arg Lys Ser Thr Leu Asn Pro Asn 725 730 735	2263
GCA AAG GAG TTC AAC CCT CGT TCT TTC TCT CAG CCA AAG CCT TCT ACT Ala Lys Glu Phe Asn Pro Arg Ser Phe Ser Gln Pro Lys Pro Ser Thr 740 745 750	2311
ACC CCA ACG TCA CCT CGG CCT CAA GCA CAA CCC AGC CCA TCT ATG GTG Thr Pro Thr Ser Pro Arg Pro Gln Ala Gln Pro Ser Pro Ser Met Val 755 760 765 770	2359
GGT CAT CAG CAG CCA GCT CCA GTG TAC ACT CAG CCT GTG TGC TTC GCA Gly His Gln Gln Pro Ala Pro Val Tyr Thr Gln Pro Val Cys Phe Ala 775 780 785	2407
CCC AAT ATG ATG TAT CCC GTC CCA GTG AGC CCG GGC GTA CAA CCT TTA Pro Asn Met Met Tyr Pro Val Pro Val Ser Pro Gly Val Gln Pro Leu 790 795 800	2455
TAC CCA ATA CCT ATG ACG CCC ATG CCT GTG AAC CAA GCC AAG ACA TAT Tyr Pro Ile Pro Met Thr Pro Met Pro Val Asn Gln Ala Lys Thr Tyr 805 810 815	2503
AGA GCA GGT AAA GTA CCA AAT ATG CCC CAA CAG CGA CAA GAC CAA CAT Arg Ala Gly Lys Val Pro Asn Met Pro Gln Gln Arg Gln Asp Gln His 820 825 830	2551
CAT CAA AGC ACC ATG ATG CAC CCA GCC TCC GCG GCA GGG CCA CCC ATC His Gln Ser Thr Met Met His Pro Ala Ser Ala Ala Gly Pro Pro Ile 835 840 845 850	2599
GTA GCC ACC CCG CCC GCT TAC TCC ACT CAG TAC GTT GCC TAC AGC CCT Val Ala Thr Pro Pro Ala Tyr Ser Thr Gln Tyr Val Ala Tyr Ser Pro 855 860 865	2647
CAG CAG TTT CCC AAT CAG CCT TTG GTC CAG CAT GTG CCG CAT TAT CAG Gln Gln Phe Pro Asn Gln Pro Leu Val Gln His Val Pro His Tyr Gln 870 875 880	2695
TCT CAG CAT CCT CAT GTG TAC AGT CCT GTC ATA CAA GGT AAT GCC AGG Ser Gln His Pro His Val Tyr Ser Pro Val Ile Gln Gly Asn Ala Arg 885 890 895	2743

ATG ATG GCA CCA CCA GCA CAT GCT CAG CCT GGT TTA GTG TCT TCT TCA Met Met Ala Pro Pro Ala His Ala Gln Pro Gly Leu Val Ser Ser Ser 900 905 910	2791
GCT GCT CAG TTC GGG GCT CAC GAG CAG ACG CAC GCC ATG TAT GCA TGT Ala Ala Gln Phe Gly Ala His Glu Gln Thr His Ala Met Tyr Ala Cys 915 920 925 930	2839
CCC AAA TTA CCA TAC AAC AAG GAG ACA AGC CCT TCT TTC TAC TTT GCC Pro Lys Leu Pro Tyr Asn Lys Glu Thr Ser Pro Ser Phe Tyr Phe Ala 935 940 945	2887
ATT TCC ACC GGC TCC CTC GCT CAG CAG TAT GCA CAT CCT AAT GCC GCC Ile Ser Thr Gly Ser Leu Ala Gln Gln Tyr Ala His Pro Asn Ala Ala 950 955 960	2935
CTG CAT CCA CAT ACT CCC CAT CCT CAG CCT TCG GCC ACT CCC ACC GGA Leu His Pro His Thr Pro His Pro Gln Pro Ser Ala Thr Pro Thr Gly 965 970 975	2983
CAG CAG CAA AGC CAG CAT GGT GGA AGT CAC CCT GCA CCC AGT CCT GTT Gln Gln Gln Ser Gln His Gly Gly Ser His Pro Ala Pro Ser Pro Val 980 985 990	3031
CAG CAC CAT CAG CAC CAG GCT GCC CAG GCT CTT CAT CTG GCC AGT CCA Gln His His Gln His Gln Ala Ala Gln Ala Leu His Leu Ala Ser Pro 995 1000 1005 1010	3079
CAG CAG CAG TCG GCC ATT TAT CAT GCG GGG CTG GCA CCA ACA CCA CCT Gln Gln Gln Ser Ala Ile Tyr His Ala Gly Leu Ala Pro Thr Pro Pro 1015 1020 1025	3127
TCC ATG ACA CCT GCC TCT AAT ACA CAG TCT CCA CAG AGC AGT TTC CCA Ser Met Thr Pro Ala Ser Asn Thr Gln Ser Pro Gln Ser Ser Phe Pro 1030 1035 1040	3175
GCA GCA CAA CAG ACA GTC TTC ACC ATC CAC CCT TCT CAT GTT CAG CCG Ala Ala Gln Gln Thr Val Phe Thr Ile His Pro Ser His Val Gln Pro 1045 1050 1055	3223
GCA TAC ACC ACC CCA CCC CAC ATG GCC CAC GTA CCT CAG GCT CAT GTA Ala Tyr Thr Thr Pro Pro His Met Ala His Val Pro Gln Ala His Val 1060 1065 1070	3271
CAG TCA GGA ATG GTT CCT TCT CAT CCA ACT GCC CAT GCG CCA ATG ATG Gln Ser Gly Met Val Pro Ser His Pro Thr Ala His Ala Pro Met Met 1075 1080 1085 1090	3319
CTA ATG ACG ACA CAG CCA CCC GGT CCC AAG GCC GCC CTC GCT CAA AGT Leu Met Thr Thr Gln Pro Pro Gly Pro Lys Ala Ala Leu Ala Gln Ser 1095 1100 1105	3367
GCA CTA CAG CCC ATT CCA GTT TCG ACA ACA GCG CAT TTC CCT TAT ATG Ala Leu Gln Pro Ile Pro Val Ser Thr Thr Ala His Phe Pro Tyr Met 1110 1115 1120	3415

ACG CAC CCT TCA GAA GCC CAC CAC CAA CAG CAG TTG TAAGGCTGCC	3464
Thr His Pro Ser Val Gln Ala His His Gln Gln Gln Leu	
1125 1130 1135	
TTGGAGGAAC CGAAAGGCCA AATCCCTTCT TCCCTTCTCT GCTTCTGCCA ACCGGAAGCA	3524
CAGAAAACTA GAACTTCATT GATTTGTGTT TTTAAAAGAT ACACTGATTT AACATCTGAT	3584
AGGAATGCTA ACAGCTCACT TGCGAGTGGAG GATGTTTG ACCGAGTAGA GGCATGTAGG	3644
GACTTGTGGC TGTTCCATAA TTCCCATGTGC TGTTGCAGGG TCCTGCAAGT ACCCAGCTCT	3704
GCTTGCTGAA ACTGGAAGTT ATTTATTTT TAATGGCCCT TGAGAGTCAT GAACACATCA	3764
GCTAGCAACA GAAGTAACAA GAGTGATTCT TGCT	3798

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1135 amino acids
- (B) TYPE: amino acid
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

Met Ser Leu Lys Pro Gln Pro Gln Pro Pro Ala Pro Ala Thr Gly Arg
1 5 10 15

Lys Pro Gly Gly Leu Leu Ser Ser Pro Gly Ala Ala Pro Ala Ser
20 25 30

Ala Ala Val Thr Ser Ala Ser Val Val Pro Ala Pro Ala Ala Pro Val
35 40 45

Ala Ser Ser Ser Ala Ala Ala Gly Gly Gly Arg Pro Gly Leu Gly Arg
50 55 60

Gly Arg Asn Ser Ser Lys Gly Leu Pro Gln Pro Thr Ile Ser Phe Asp
65 70 75 80

Gly Ile Tyr Ala Asn Val Arg Met Val His Ile Leu Thr Ser Val Val
85 90 95

Gly Ser Lys Cys Glu Val Gln Val Lys Asn Gly Gly Ile Tyr Glu Gly
 100 105 110

Val Phe Lys Thr Tyr Ser Pro Lys Cys Asp Leu Val Leu Asp Ala Ala
115 120 125

His Glu Lys Ser Thr Glu Ser Ser Ser Gly Pro Lys Arg Glu Glu Ile
130 135 140

Met Glu Ser Val Leu Phe Lys Cys Ser Asp Phe Val Val Val Gln Phe
145 150 155 160

Lys Asp Thr Asp Ser Ser Tyr Ala Arg Arg Asp Ala Phe Thr Asp Ser
165 170 175

Ala Leu Ser Ala Lys Val Asn Gly Glu His Lys Glu Lys Asp Leu Glu
180 185 190

Pro Trp Asp Ala Gly Glu Leu Thr Ala Ser Glu Glu Leu Glu Leu Glu
195 200 205

Asn Asp Val Ser Asn Gly Trp Asp Pro Asn Asp Met Phe Arg Tyr Asn
210 215 220

Glu Glu Asn Tyr Gly Val Val Ser Thr Tyr Asp Ser Ser Leu Ser Ser
225 230 235 240

Tyr Thr Val Pro Leu Glu Arg Asp Asn Ser Glu Glu Phe Leu Lys Arg
245 250 255

Glu Ala Arg Ala Asn Gln Leu Ala Glu Glu Ile Glu Ser Ser Ala Gln
260 265 270

Tyr Lys Ala Arg Val Ala Leu Glu Asn Asp Asp Arg Ser Glu Glu Glu
275 280 285

Lys Tyr Thr Ala Val Gln Arg Asn Cys Ser Asp Arg Glu Gly His Gly
290 295 300

Pro Asn Thr Arg Asp Asn Lys Tyr Ile Pro Pro Gly Gln Arg Asn Arg
305 310 315 320

Glu Val Leu Ser Trp Gly Ser Gly Arg Glu Ser Ser Pro Arg Met Gly
325 330 335

Gln Pro Gly Pro Gly Ser Met Pro Ser Arg Ala Ala Ser His Thr Ser
340 345 350

Asp Phe Asn Pro Asn Ala Gly Ser Asp Gln Arg Val Val Asn Gly Gly
355 360 365

Val Pro Trp Pro Ser Pro Cys Pro Ser His Ser Ser Arg Pro Pro Ser
370 375 380

Arg Tyr Gln Ser Gly Pro Asn Ser Leu Pro Pro Arg Ala Ala Thr His
385 390 395 400

Thr Arg Pro Pro Ser Arg Pro Pro Ser Arg Pro Ser Arg Pro Pro Ser
405 410 415

His Pro Ser Ala His Gly Ser Pro Ala Pro Val Ser Thr Met Pro Lys
420 425 430

Arg Met Ser Ser Glu Gly Pro Pro Arg Met Ser Pro Lys Ala Gln Arg
435 440 445

His Pro Arg Asn His Arg Val Ser Ala Gly Arg Gly Ser Met Ser Ser
450 455 460

Gly Leu Glu Phe Val Ser His Asn Pro Pro Ser Glu Ala Ala Ala Pro
465 470 475 480

Pro Val Ala Arg Thr Ser Pro Ala Gly Gly Thr Trp Ser Ser Val Val
485 490 495

Ser Gly Val Pro Arg Leu Ser Pro Lys Thr His Arg Pro Arg Ser Pro
500 505 510

Arg Gln Ser Ser Ile Gly Asn Ser Pro Ser Gly Pro Val Leu Ala Ser
515 520 525

Pro Gln Ala Gly Ile Ile Pro Ala Glu Ala Val Ser Met Pro Val Pro
530 535 540

Ala Ala Ser Pro Thr Pro Ala Ser Pro Ala Ser Asn Arg Ala Leu Thr
545 550 555 560

Pro Ser Ile Glu Ala Lys Asp Ser Arg Leu Gln Asp Gln Arg Gln Asn
565 570 575

Ser Pro Ala Gly Ser Lys Glu Asn Val Lys Ala Ser Glu Thr Ser Pro
580 585 590

Ser Phe Ser Lys Ala Asp Asn Lys Gly Met Ser Pro Val Val Ser Glu
595 600 605

His Arg Lys Gln Ile Asp Asp Leu Lys Lys Phe Lys Asn Asp Phe Arg
610 615 620

Leu Gln Pro Ser Ser Thr Ser Glu Ser Met Asp Gln Leu Leu Ser Lys
625 630 635 640

Asn Arg Glu Gly Glu Lys Ser Arg Asp Leu Ile Lys Asp Lys Thr Glu
645 650 655

Ala Ser Ala Lys Asp Ser Phe Ile Asp Ser Ser Ser Ser Ser Asn
660 665 670

Cys Thr Ser Gly Ser Ser Lys Thr Asn Ser Pro Ser Ile Ser Pro Ser
675 680 685

Met Leu Ser Asn Ala Glu His Lys Arg Gly Pro Glu Val Thr Ser Gln
690 695 700

Gly Val Gln Thr Ser Ser Pro Ala Cys Lys Gln Glu Lys Asp Asp Arg
705 710 715 720

Glu Glu Lys Lys Asp Thr Thr Glu Gln Val Arg Lys Ser Thr Leu Asn
725 730 735

Pro Asn Ala Lys Glu Phe Asn Pro Arg Ser Phe Ser Gln Pro Lys Pro
740 745 750

Ser Thr Thr Pro Thr Ser Pro Arg Pro Gln Ala Gln Pro Ser Pro Ser
755 760 765

Met Val Gly His Gln Gln Pro Ala Pro Val Tyr Thr Gln Pro Val Cys
770 775 780

Phe Ala Pro Asn Met Met Tyr Pro Val Pro Val Ser Pro Gly Val Gln
785 790 795 800

Pro Leu Tyr Pro Ile Pro Met Thr Pro Met Pro Val Asn Gln Ala Lys
805 810 815

Thr Tyr Arg Ala Gly Lys Val Pro Asn Met Pro Gln Gln Arg Gln Asp
820 825 830

Gln His His Gln Ser Thr Met Met His Pro Ala Ser Ala Ala Gly Pro
835 840 845

Pro Ile Val Ala Thr Pro Pro Ala Tyr Ser Thr Gln Tyr Val Ala Tyr
850 855 860

Ser Pro Gln Gln Phe Pro Asn Gln Pro Leu Val Gln His Val Pro His
865 870 875 880

Tyr Gln Ser Gln His Pro His Val Tyr Ser Pro Val Ile Gln Gly Asn
885 890 895

Ala Arg Met Met Ala Pro Pro Ala His Ala Gln Pro Gly Leu Val Ser
900 905 910

Ser Ser Ala Ala Gln Phe Gly Ala His Glu Gln Thr His Ala Met Tyr
915 920 925

Ala Cys Pro Lys Leu Pro Tyr Asn Lys Glu Thr Ser Pro Ser Phe Tyr
930 935 940

Phe Ala Ile Ser Thr Gly Ser Leu Ala Gln Gln Tyr Ala His Pro Asn
945 950 955 960

Ala Ala Leu His Pro His Thr Pro His Pro Gln Pro Ser Ala Thr Pro
965 970 975

Thr Gly Gln Gln Ser Gln His Gly Gly Ser His Pro Ala Pro Ser
980 985 990

Pro Val Gln His His Gln His Gln Ala Ala Gln Ala Leu His Leu Ala
995 1000 1005

Ser Pro Gln Gln Gln Ser Ala Ile Tyr His Ala Gly Leu Ala Pro Thr
1010 1015 1020

Pro Pro Ser Met Thr Pro Ala Ser Asn Thr Gln Ser Pro Gln Ser Ser
1025 1030 1035 1040

Phe Pro Ala Ala Gln Gln Thr Val Phe Thr Ile His Pro Ser His Val
1045 1050 1055

Gln Pro Ala Tyr Thr Thr Pro Pro His Met Ala His Val Pro Gln Ala
1060 1065 1070

His Val Gln Ser Gly Met Val Pro Ser His Pro Thr Ala His Ala Pro
1075 1080 1085

Met Met Leu Met Thr Thr Gln Pro Pro Gly Pro Lys Ala Ala Leu Ala
1090 1095 1100

Gln Ser Ala Leu Gln Pro Ile Pro Val Ser Thr Thr Ala His Phe Pro
1105 1110 1115 1120

Tyr Met Thr His Pro Ser Val Gln Ala His His Gln Gln Gln Leu
1125 1130 1135

That which is claimed is:

1. Isolated nucleic acid encoding a mammalian SCA2 polypeptide.
2. Isolated nucleic acid according to claim 1, wherein said nucleic acid comprises DNA.
3. DNA according to claim 2, wherein said DNA is a cDNA.
4. DNA according to claim 2, wherein said DNA encodes at least about 10 contiguous amino acids set forth in SEQ ID NO:3, or SEQ ID NO:5.
5. DNA according to claim 2, wherein said DNA hybridizes under high stringency conditions to the SCA2 coding portion of nucleotides 1 - 516 of SEQ ID NO:1 or nucleotides 163-4098 of SEQ ID NO:2 , or nucleotides 50-3454 of SEQ ID NO:4.
6. DNA according to claim 2, wherein said DNA has substantially the same nucleotide sequence as the SCA2 coding portion set forth in SEQ ID NO:2, or SEQ ID NO:4 .
7. A vector comprising DNA according to claim 2.
8. A host cell containing a vector according to claim 7, wherein said cell is a procaryotic cell or a eucaryotic cell.
9. A host cell according to claim 8, wherein said cell expresses a functional SCA2 protein.

10. An oligonucleotide comprising at least 15 nucleotides capable of specifically hybridizing with a sequence of nucleic acids of the nucleotide sequence set forth in SEQ ID NO:2, or SEQ ID NO:4.

11. An oligonucleotide according to claim 10, wherein said oligonucleotide is labeled with a detectable marker.

12. A kit for detecting mutations and in chromosome 12 at the SCA2 locus in 12q24.1 comprising at least one oligonucleotide according to claim 10.

13. Isolated mRNA complementary to DNA according to claim 2.

14. An oligonucleotide composition comprising chemical analogues of the nucleic acid of claim 2 operatively linked to a promoter of RNA transcription.

15. An antisense oligonucleotide capable of specifically binding to and inhibiting the translation of mRNA according to claim 13.

16. Isolated SCA2 polypeptide, or fragments thereof, and functional equivalents thereof.

17. Isolated SCA2 polypeptide according to claim 16, wherein said polypeptide comprises substantially the same amino acid sequence as that set forth in SEQ ID NO:3, amino acids 1-165 or amino acids 188-1312 of SEQ ID NO:3, or substantially the same amino acid sequence as that set forth in SEQ ID NO:5.

18. Isolated SCA2 polypeptide according to claim 16, wherein said polypeptide has the same amino acid sequence as that set forth in SEQ ID NO:3, or at least amino acids 1-165 or amino acids 188-1312 of SEQ ID NO:3, or in SEQ ID NO:5.

19. Isolated SCA2 polypeptide according to claim 16, wherein said polypeptide is encoded by a nucleotide sequence that is substantially the same nucleotide sequence as that set forth in SEQ ID NO:2, nucleotides 163-4098 of SEQ ID NO:2, SEQ ID NO:4, or nucleotides 50-3454 of SEQ ID NO:4.

20. Isolated SCA2 polypeptide according to claim 16, wherein said polypeptide is encoded by at least nucleotides 163-4098 set forth in SEQ ID NO:2, or at least nucleotides 50-3454 of SEQ ID NO:4.

21. An SCA2 polypeptide expressed recombinantly in a host cell.

22. An SCA2 polypeptide according to claim 21, wherein said polypeptide is encoded by a nucleotide sequence that is substantially the same as at least nucleotides 163-4098 set forth in SEQ ID NO:2, or at least nucleotides 50-3454 of SEQ ID NO:4.

23. An SCA2 polypeptide according to claim 21, wherein said polypeptide is encoded by at least nucleotides 163-4098 set forth in SEQ ID NO:2, or at least nucleotides 50-3454 of SEQ ID NO:4.

24. An antibody that specifically binds to a determinant on a SCA2 polypeptide according to claim 16, or active fragment thereof.

25. An antibody according to claim 24, wherein said antibody is a monoclonal antibody.

26. An antibody according to claim 24, wherein said antibody is a polyclonal antibody.

27. A composition comprising an amount of the antisense oligonucleotide according to claim 13 effective to modulate expression of a human SCA2 polypeptide and an acceptable hydrophobic carrier capable of passing through a cell membrane.

28. A composition according to claim 27, wherein the oligonucleotide is coupled to a substance which inactivates mRNA.

29. A composition according to claim 28, wherein said substance is a ribozyme.

30. A composition comprising an amount of an antibody according to claim 24 effective to block function of the SCA2 protein or to block interaction of the SCA2 protein with other proteins or ligands.

31. A transgenic nonhuman mammal expressing DNA encoding a SCA2 polypeptide according to claim 2.

32. A transgenic nonhuman mammal according to claim 31, wherein said DNA encoding said polypeptide has been mutated as to be incapable of normal polypeptide activity, and wherein the polypeptide so expressed is not native SCA2 polypeptide.

33. A transgenic nonhuman mammal, the genome of which comprising antisense DNA complementary to DNA encoding a SCA2 polypeptide according to claim 2, wherein said antisense DNA is transcribed into antisense mRNA complementary to mRNA encoding a human SCA2 polypeptide.

34. A transgenic nonhuman mammal according to claim 31, wherein said DNA is operatively linked to an inducible promoter.

35. A transgenic nonhuman mammal according to claim 31, wherein said DNA is operatively linked to tissue specific regulatory elements.

36. A transgenic nonhuman mammal according to claim 31, wherein the transgenic nonhuman mammal is a mouse.

37. A method for identifying nucleic acids encoding a human SCA2 protein, said method comprising:
contacting a sample containing nucleic acids with a probe according to claim 11, wherein said contacting is effected under high stringency hybridization conditions, and identifying compounds which hybridize thereto.

38. A method for identifying compound(s) which bind to a human SCA2 polypeptide, said method comprising contacting cells according to claim 9 with said compound(s) and identifying compounds which bind thereto.

39. A method for detecting the presence of a human SCA2 polypeptide, said method comprising contacting a test sample with an antibody according to claim 24, detecting the presence of an antibody-SCA2 complex, and therefor detecting the presence of a human SCA2 polypeptide in said test sample.

40. Single strand DNA primers for amplification diagnosis of SCA2, wherein said primers comprise a nucleic acid sequence derived from the nucleic acid according to claim 1 set forth as SEQ ID NO:2, or SEQ ID NO:4.

41. A method for diagnosing spinocerebellar Ataxia Type 2, said method comprising:

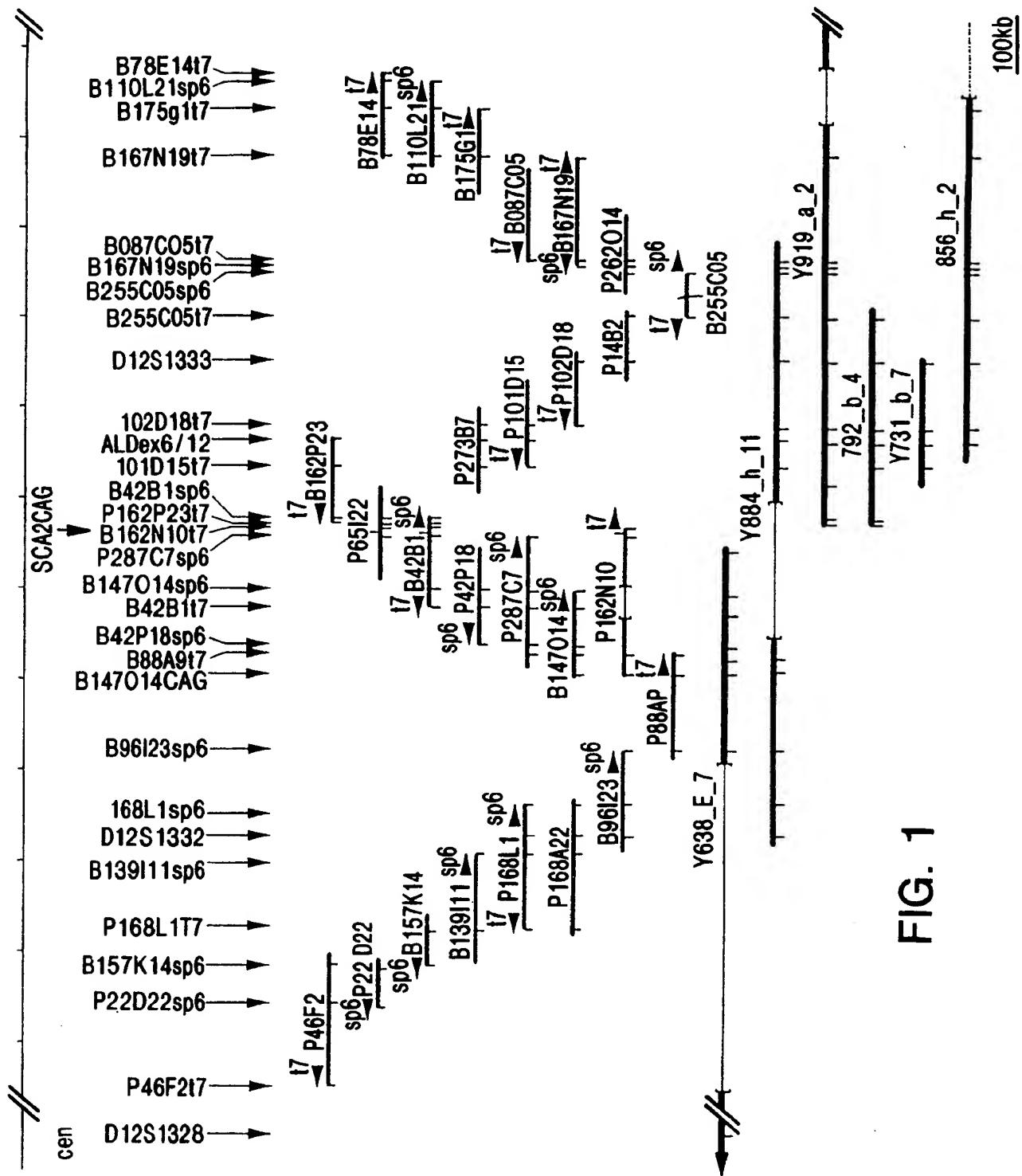
detecting, in said subject, a genomic or transcribed mRNA sequence having an expanded CAG repeat at a location corresponding to between nucleotides 657 and 724 of SEQ ID NO:2.

42. A method for diagnosing spinocerebellar Ataxia Type 2, said method comprising:

a) contacting nucleic acid obtained from a subject suspected of having SCA2 with primers that amplify at least a nucleic acid fragment of SEQ ID NO:2 containing nucleotides 658-723 of SEQ ID NO:2, under conditions suitable to form a detectable amplification product; and

b) detecting an amplification product containing substantially expanded CAG repeats above normal, whereby said detection indicates that said subject has SCA2.

43. A diagnostic kit comprising at least one oligonucleotide according to claim 10 contained in a packaging material.



1

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1 TTGGTAGAACGGAAACGGCGGCCGCGCTTCGGCCGGCTCCGGCTCCTGGTC
61 TCGGCAGGGCCTCCCCGCCCTCGTCGTCTCCTCTCCCCCTGCCAGCCCCGGCGCC
121 CTCCGGCCGCGCCAACCCGCGCCTCCCCGCTCGGCGCCGTGCGTCCCCGCCCGTCCG
181 GCGTCTCCTTGGCGCGCCGGCTCCGGCTGTCCCCGCCGGTGCAGGCCGGTGTATG

          SCA2-A
241 GGCCCCCTCACCATGTCGCTGAAGCCCCAGCAGCAGCAGCAGCAGCAGCAACAGCAGC

          SCA2-B
301 AGCAGCAACAGCAGCAGCAGCAGCAGCAGCAGCAGGCCGCCGCCGGCTGCCAATGTCCGCA
361 AGCCCCGGCAGCGGGCTTCTAGCGTCGCCGCCGCCCTCGCCGTCTCGTCCTCGTCC
421 CGGTCTCCTCGTCCTCGGCCACGGCTCCCTCCTCGGTGGTCGGCGACCTCCGGCGCG
481 GGAGGCCCGGCCTGGCAG GTGGGTGTGGCACCCC

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FIG. 2

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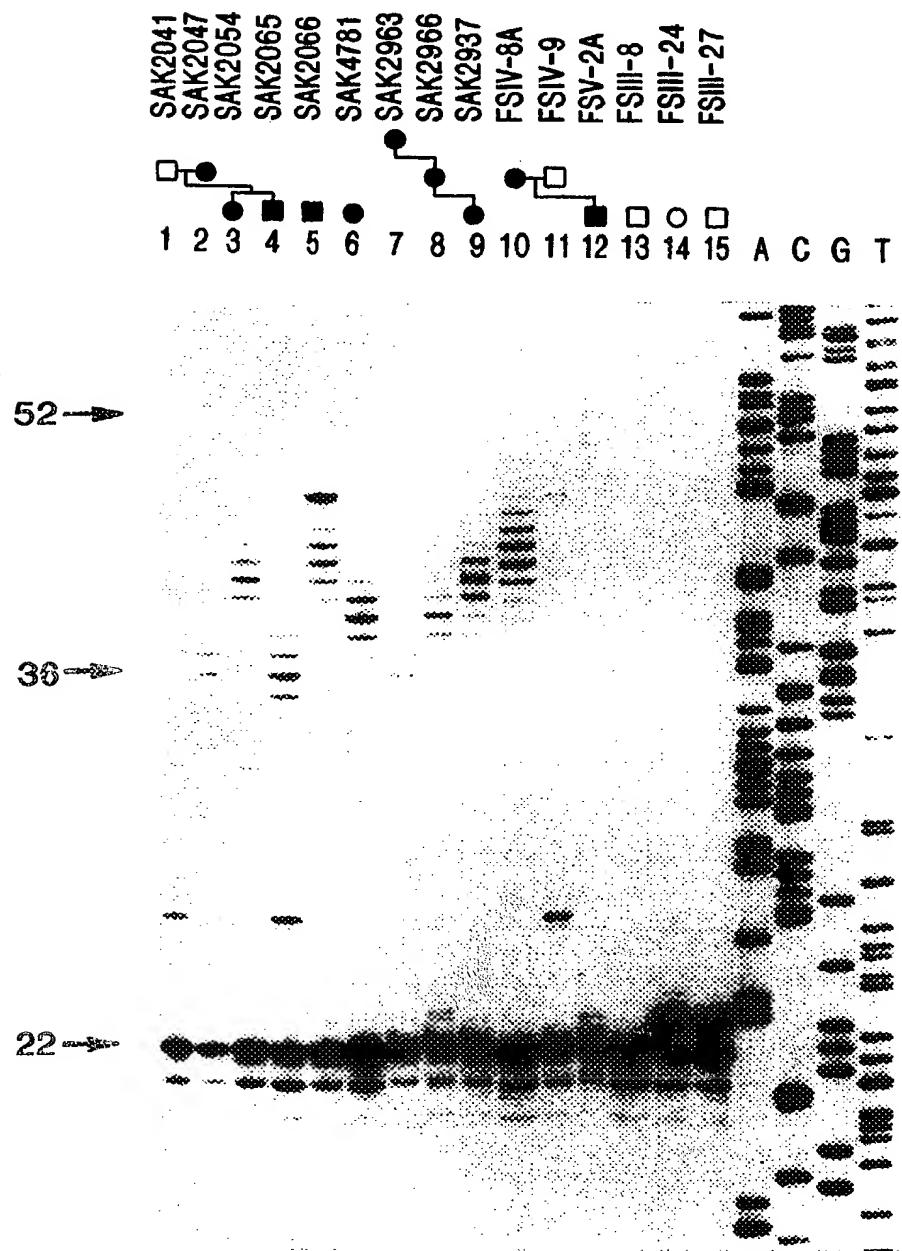


FIG. 3

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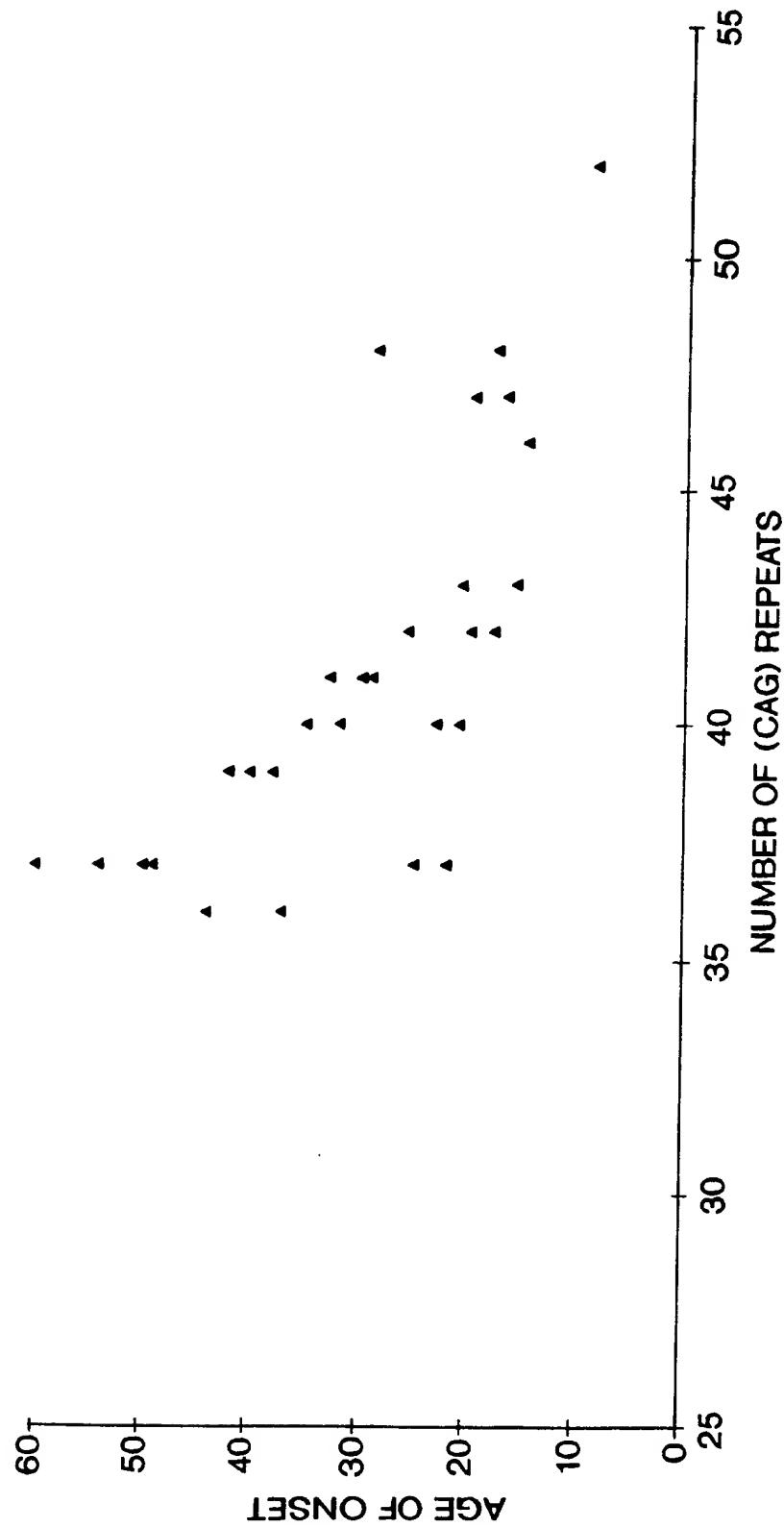


FIG. 4

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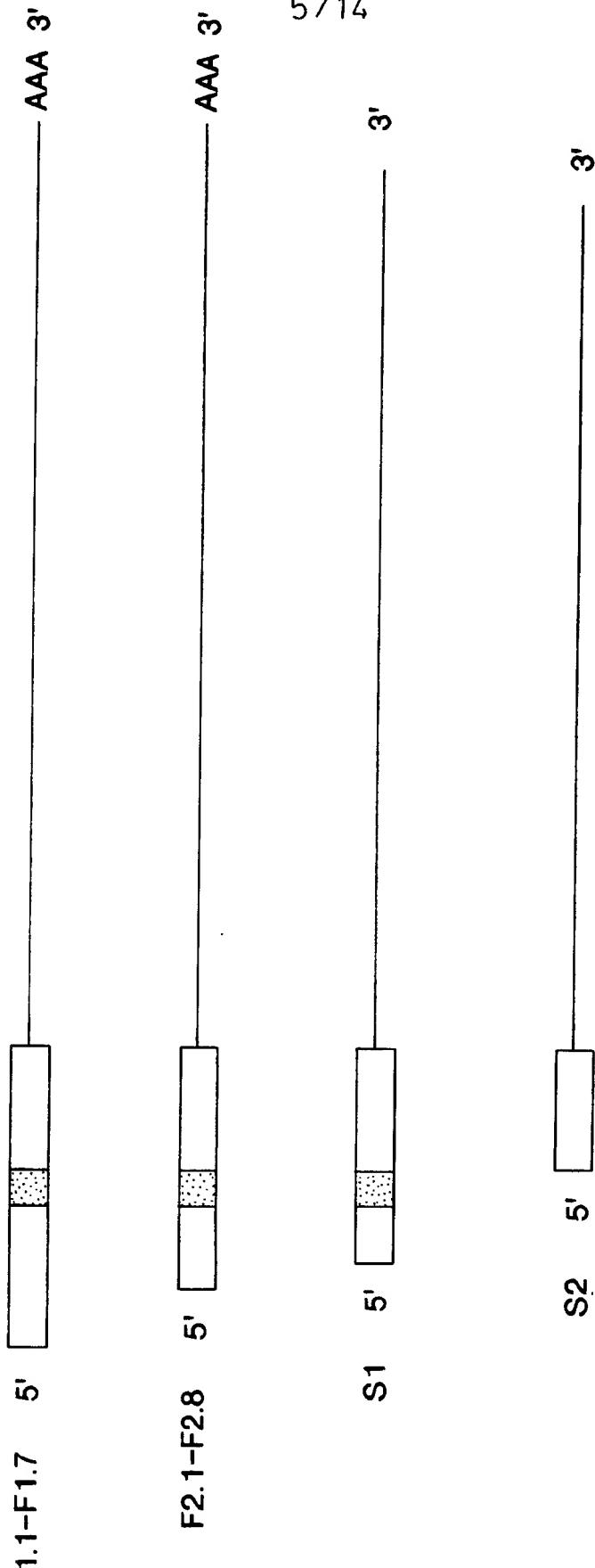


FIG. 5

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1	ACCCCGAGAAAGCAACCCAGGGCGGCCCGGTCTCACGTGTCCTCCCCGGGG	60
61	GCCACCTCAGGTTCTGCTTCCGCTCTGACCCCTCCGACTTCCGGTAAAGAGTCCCTATCCG	120
*		
121	CACCTCCGGCTCCACCCGGGCCTCGGGCGCCCTCCGATGGCTCAGGGCGCA	180
1		
181	GCTCCTGGAGTCCCCGGGCCACCGAGTCTGGCCGCTTCAGCCAGGGTGGCCC	240
7	A P R S P A V A T E S R R F A A R W P	26
241	GGGTGGGCTCGCTCCAGCGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGG	300
27	G W R S L Q R P A R R S G R G G G A A	46
301	CGGGGACCGTATCCCTCGCCGCCCTCCCGCCCCCGCCCCCGCCCCCGCCCC	360
47	P G P Y P S A A P P P G P P P S R	66
361	CAGAGGCTGGCTCCCTCGGCTCAGACTGTTGGTAGCAACGGCAAACGGGGGGGGGG	420
67	Q S S P P S A S D C F G S N G N G G A	86
421	TTTCGGCCCCGGCTCCGGGGGCTCCTGGTCTCGGGGGCTCCCGCCCTCGTC	480
87	F R P G S R R L L G L G P P R F V	106
481	GTCCCTTCTCCCCCTCGCCAGCCCCGGGGGGGGGGGGCAACCGGGCCTCCCCG	540
107	V L L P L A S P G A P P A P T R A S P	126
541	CTCGGGCCCCGGTGGGTCCCCGGGGTCTCCCTGGGGGGGGCTCCGGGG	600
127	L G A R A S P P R S G V S L A R P A P G	146
	SCA2-A	
601	TGTCCCCGGGGTGGGAGCCGGTATGGGCCCTCACCATGTCAGGGCCAG	660
147	C P R P A C E P V Y G P L T M S L K P Q	166
661	CAGGAGGAGGAGGAGGAGGAGGAGGAGGAGGAGGAGGAGGAGGAGGAG	720
167	Q Q	186

FIG. 6A

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	SCA2-B										
721	CAGCGCCGGCTGCCAATGTCGGCAAGCCC	G	GGCC	780							
187	Q P P A A N V R K P G G S G L L A S										206
781	CCC GG CG CC CT T G G C C T C G G T C C T C G G T C C T C G G C C A C G G C T C C										840
207	P A A P S P S S V S S S A T A P										226
841	TCCTCGGTGGTGGCTCGGGCGACCTCCGGGGAGGGCCCTGGGAGAGGTGAAAC										900
227	S S V V A A T S G G G R P G L G R N										246
901	AGTAACAAAGGACTGCCTCAGTCTACGGATTCTATGGAATCTATGCAAATATGAGG										960
247	S N K G L P Q S T I S F D G I Y A N M R										266
961	ATGGTTCATATACTTACATCAGTTGTTGGCTCCAAATGTGAAGTACAAGTGAATGGA										1020
267	M V H I L T S V V G S K C E V Q V K N G										286
	SCA2-14B										
1021	GGTATATGAAAGGAGTTTTAAACCTTACAGTCCGAAGTGTGATTGGTACTTGATGCC										1080
287	G I Y E G V F K T Y S P K C D L V L D A										306
1081	GCACATGAGAAAAGTACAGAAATCCAGTTGGGGCGAAACGTGGAAATAATGGAGAGT										1140
307	A H E K S T E S S G P K R E E I M E S										326
1141	ATTTGTTCAAATGTTCAAGACTTTGTTGTAACAGTTAAAGATATGGACTCCAGTTAT										1200
327	I L F K C S D F V V Q F K D M D S S Y										346
1201	GCAAAAGAGATGCTTTACTGACTCTGCTATCAGTGTCTAAAGTGAATGGCAACACAAA										1260
347	A K R D A F T D S A I S A K V N G E H K										366
1261	GAGAAGGACCTGGAGCCCTGGGATGCAAGGTGAACCTCACAGCCAATGAGGAACCTGGGCT										1320
367	E K D L E P W D A G E L T A N E E L E A										386
1321	TTGGAAAATGACGTATACTGATGGATGGGATCCCAATGATATGTTCGATAATAATGAAGAA										1380
387	L E N D V S N G W D P N D M F R Y N E E										406
1381	AATTATGGTGTAGTGTCTACGTATGATGGCAGTTATCTTCGTATACTGTCCTTAGAA										1440
407	N Y G V V S T Y D S S L S S Y T V P L E										426
1441	AGAGATAACTCAGAAGAAATTAAAACGGGAAGGCAAGGGCAAAACCAGTTAGCAGAAGAA										1500
427	R D N S E E F L K R E A R A N Q L A E E										446

FIG. 6B**SUBSTITUTE SHEET (RULE 26)**

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1501	ATTGAGTCAGTGCCCAAGTACAAAGCTCGAGTGGCCCTGGAAAATGATAGGAGTGAG	1560
447	I E S S A Q Y K A R V A L E N D D R S E	466
1561	GAAGAAAAATAACAGCAGTTAGAGAAATTCCAGTGAAACGTGAGGGCACAGGCTAAAC	1620
467	E E K Y T A V Q R N S S E R E G H S I N	486
1621	ACTAGGGAAAATAAATATTCCCTCTGGACAAAGAAATAGAGAAAGTCATATCCCTGGGA	1680
487	T R E N K Y I P P G Q R N R E V I S W G	506
1681	AGTGGGAGACAGAATTCAACCGGGTATGGGCCAGCCTGGATGGGCTCCATGCCATCAAGA	1740
507	S G R Q N S P R M G Q P G S G S M P S R	526
1741	TCCACTTCTCACACTTCAGATTCAACCGAATTCTGGTTCAAGACCAAAGAGTAGTTAAT	1800
527	S T S H T S D F N P N S G S D Q R V V N	546
1801	GGAGGGTTCCCTGGCCATGCCCTGGCCATCTCCCTCTCCTCCCTGGCTAC	1860
547	G G V P W P S P C P S P S R P P S R Y	566
1861	CAGTCAGGTCCCCAACTCTTCCACCTCGGCAGGCCACCCCTACACGGCCGCCCTCCAGG	1920
567	Q S G P N S L P P R A A T P T R P P S R	586
1921	CCCCCCTGGGCCATCCAGACCCCCGGTCTCACCCCTCTGCTCATGGTTCTCCAGCTCCT	1980
587	P P S R P S R P P S H P S A H G S P A P	606
1981	GTCTCTACTATGCCTAAACGCATGTCITTCAGAAGGGCCCTCCAAGGGATGTCCCCAAGGCC	2040
607	V S T M P K R M S S E G P P R M S P K A	626
2041	CAGGGACATCCTCGAAATCACAGAGTTCTGCTGGGGTCCATATCCAGTGGCCTA	2100
627	Q R H P R N H R V S A G R G S I S S G L	646
2101	GAATTGTATCCCACAACCCACCCAGTGAAGCAGCTACTCCTCCAGTAGCAAGGACCAGT	2160
647	E F V S H N P P S E A A T P P V A R T S	666
2161	CCCTGGGGGAACGTGGTCATCAGTGGTCAGTGGTTCCAAGATTATCCCCTAAACT	2220
667	P S G G T W S S V V S G V P R L S P K T	686
2221	CATAGACCCAGGTCTCCAGACAGAACAGTATTGGAAATAACCCCCAGTGGCCAGTGTCTT	2280
687	H R P R S P R Q N S I G N T P S G P V L	706

FIG. 6C

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2281	GCTTCTCCCCAAGCTGGTATTATCCAACTGAAAGCTGTTGCCATGCCATTTCAGCTGCA	2340
707	A S P Q A G I I P T E A V A M P I P A A	726
2341	TCTCCTACGGCCTAGTCCTGCATCGAACAGAGCTGTTACCCCTTCTAGTGAGGCTAAA	2400
727	S P T P A S P A S N R A V T P S S E A K	746
2401	GATTCCAGGGCTTCAAGATCAGAGGCAGAACACTCTCCTGCCAGGGATAAGAAAATATAAA	2460
747	D S R L Q D Q R Q N S P A G N K E N I K	766
2461	CCCAATGAAACATCACCTAGCTTCTCAAAAGCTGAAACAAGGTATATCACCAGTTGT	2520
767	P N E T S P S F S K A E N K G I S P V V	786
2521	TCTGAAACATAGAAACAGATTGATTAAAGAAATTAAAGAATGATTITAGGTTACAG	2580
787	S E H R K Q I D D L K K F K N D F R L Q	806
2581	CCAAGTTCTACTTCTGAATCTATGGATCAACTACTAAACAAAAATAGAGGGAGAAAAA	2640
807	P S S T S E S M D Q L L N K N R E G E K	826
2641	TCAAAGAGATTGATCAAAAGACAAATTGAACCCAAGTGTAAAGGATTCTTCAATTGAAAT	2700
827	S R D L I K D K I E P S A K D S F I E N	846
2701	AGCAGCAGCAACTGTACCGTAGGGCAGCAGCAAGCCGAATAGCCCCAGCATTCCCTCA	2760
847	S S N C T S G S S K P N S P S I S P S	866
2761	ATACTTAGTAACACGGAGCCAAGAGGGGACCTGAGGTCACTTCCCAGGGGTTCAGACT	2820
867	I L S N T E H K R G P E V T S Q G V Q T	886
2821	TCCAGCCCAGGCATGTAAACAGAGAAAGACGATAAGGAAGAGAAAGACGCAGCTGAG	2880
887	S S P A C K Q E K D D K E E K K D A A E	906
2881	CAAGTTAGGAAATCAACATTGAATCCCAATGCAAAGGAGTTCAACCCACAGTTCTCT	2940
907	Q V R K S T L N P N A K E F N P R S F S	926
2941	CAGCCAAAGCCTTCTACTACCCCAACTTCACCTCGGCCTCAAGCACAACTAGCCCATCT	3000
927	Q P K P S T T P T S P R P Q A Q P S P S	946
3001	ATGGTGGGTCAATCAACAGCCAACTCCAGTTATACTCAGCCTGTTGTTGCACCAAAT	3060
947	M V G H Q Q P T P V Y T Q P V C F A P N	966
3061	ATGATGTATCCAGTCCCCAGTGAGGCCAGGGGTGCAACCTTATACCCATACTATGACG	3120
967	M M Y P V P V S P G V Q P L Y P I P M T	986

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FIG. 6D

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3121	CCCATGCCAGTGAATCAAGCCAAGACATATA	GAGCAGTACCAAAATATGCC	CCCCAACAGCGGG	3180
987	P M P V N Q A K T Y R A V P N M	P Q Q R	1006	
3181	CAAGACCAGCATCATCAGAGTGCCATG	CACCCAGCGGT	CAGCGGGCCACCGATT	3240
1007	Q D Q H H Q S A M M H P A S A A G	P P I	1026	
3241	GCAGCCCACCCACCAGCTTACTCCACG	CAATATGTTGCC	TACAGTCCTCAGCAGTCCCA	3300
1027	A A T P P A Y S T Q Y V A Y S P Q	Q F P	1046	
3301	AATCAGCCCCCTGTTCA	GCTCATGCTCTCATG	TCTATACTAGT	3360
1047	N Q P L V Q H V P H Y Q S Q H P H	V Y S	1066	
3361	CCTGTAATACAGGGTAATGCTAGAAT	ATGGCACCAAC	ACACAGGCCAGCCTGGTTA	3420
1067	P V I Q G N A R M M A P P T H A Q	P G L	1086	
3421	GTATCTTCTCAGCAA	CTCAGTACGGG	GCTCATGAGCAGACGGCATGCGATGTATGCATGT	3480
1087	V S S A T Q Y G A H E Q T H A M Y	A C	1106	
3481	CCCAAATTACCATACAAGGAGACAAG	CCCCCTTCTTCTACTTTGCC	ATTTCCACGGGC	3540
1107	P K L P Y N K E T S P S F Y F A I	S T G	1126	
3541	TCCCCCTGCTCAGGAGTATGCC	CACCCCTAACG	GCTAACATCTCCACACCC	3600
1127	S L A Q Q Y A H P N A T L H P H T P	H P	1146	
3601	CAGCCTTCAGCTACCCCCACTGGACAG	GAGCAAGCC	AAACATGGTGGAAAGTCATCCTGCA	3660
1147	Q P S A T P T G Q Q S Q H G S H P A	1166		
3661	CCCAGTCTGTTCA	GGACCATTAGCACC	AGGCCAGGGCTCTCCATCTGGCCAGTCCA	3720

FIG. 6E

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1167	P	S	P	V	Q	H	H	Q	H	Q	A	Q	A	L	H	L	A	S	P	1186	
3721	CAGCAGGAGTCAGGCCATTACCAACGGGGCTTGCGCCAACTCCACCCCTCCATGACACCT	3780																			
1187	Q	Q	S	A	I	Y	H	A	G	L	A	P	T	P	P	S	M	T	P	1206	
3781	GCCTCCAACACGGCAGTCGCCAACAGAATAAGTTCCCAGCAGCACACAGACTGTCTTACG	3840																			
1207	A	S	N	T	Q	S	P	Q	N	S	F	P	A	A	Q	Q	T	V	F	T	1226
3841	ATCCCATCCTTCTCACGGTTCACGGGGTACCAACCCACCCACATGGCCCCACGTACCT	3900																			
1227	I	H	P	S	H	V	Q	P	A	Y	T	N	P	P	H	M	A	H	V	P	1246
3901	CAGGCTCATGTACAGTCAGGAATGGTTCTCATCCAAACTGGCCCATGGGCCAATGATG	3960																			
1247	Q	A	H	V	Q	S	G	M	V	P	S	H	P	T	A	H	A	P	M	M	1266
3961	CTAATGACGACACAGCCACCCCCGGGTCCCCAGGGCGCCCTCGCTCAAAGTGCACACAG	4020																			
1267	L	M	T	T	Q	P	P	G	G	P	Q	A	A	L	A	Q	S	A	L	Q	1286
4021	CCCATTCAGTCTCGACAACAGGGCATTTCCCTTATATGACGGCACCCCTTCAGTACAAGCC	4080																			
1287	P	I	P	V	S	T	T	A	H	F	P	Y	M	T	H	P	S	V	Q	A	1306
4081	CACCAACAGCAGTTGTAAGGGCTGCCCTGGAGGAACCGAAAGGCCAATTCCCTCCTC	4140																			
1307	H	H	Q	Q	Q	L	*														1326
4141	CCTTCTACTGCTTCTACCAACTGGAAAGCACAGAAAACTAGAAATTTCATTATTTTGT	4200																			
4201	TAAAATATATGTTGATTCTGTAAACATCCAAATGGAATGCTAACAGTTCACITGCAG	4260																			
4261	TGGAAAGATACTTGGACCCGAGTAGAGGCATTAGGAACACTGGGGCTATTCCATAATTCCA	4320																			
4321	TATGGCTGTTCAAGAGTCCCCGAGGTACCCAGCTCTGCTGCCGAAACTGAAAGTTATT	4380																			
4381	ATTTTTAATAACCCCTTGAAAGTCATGAAACACATCAGCTAACAGTAACAGAGT	4440																			
4441	GATTCTTGCTTACTGCTAAAAAAGCTAAAGTGTAAAAAAAGAAAAAA	4481																			

FIG. 6F

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Ataxin-2	VYGPLTMSLK	PQQQQQQQQQ	QQQQQQQQQQ	QQQPPAAAN	VRKPGGSGLL	50
Mouse Ataxin-2	HEGPLTMSLK	PQPQ.	PPAPAT	GRKPGG.GLL
A2RP	.....	LA	PQPPPQQHQ	ER.	.....	.....
Consensus	-----L-	PQ--	-----	-----	-----	-----
Ataxin-2	ASPAAAPSPS	SSSVSSSSAT	APSSWVA..	ATSGGGRPGL	GRGRNSNKGL	100
Mouse Ataxin-2	SSPGAAP.AS	AAVTSASVVP	APAAPPVASSS	AAAAGGGRPGL	GRGRNSSKGL	
A2RP	..PGAAAIGS	A.....	.....	.....	..	.RGQSTGKGP
Consensus	--P-AA--S	-----	-----	-----	-----	-RG---KG--
Ataxin-2	PQSTISFDGI	YANVRMVHIL	TSVVGSKCEV	QVKNGGIYEG	VFKTYSPKCD	101
Mouse Ataxin-2	PQPTISFDGI	YANVRMVHIL	TSVVGSKCEV	QVKNGGIYEG	VFKTYSPKCD	
A2RP	PQSPV.FEGV	YNNSRMLHFL	TAVVGSTCDV	KVKNGTTYEG	IFKTLSSKFE	
Consensus	PQ---F-G-	Y-N-RM-H-L	T-VVGS-C-V	-VKQIG--YEG	-FKT-S-K--	
Ataxin-2	LVLDAHEKS	TESSSGPKRE	EIMESILFKC	SDFVVVQFKD	MDSSSYAKRDA	151
Mouse Ataxin-2	LVLDAHEKS	TESSSGPKRE	EIMESVLFKC	SDFVVVQFKD	TDSSSYARRDA	
A2RP	LAVDAVHRKA	SEPAGGPREE	DIVDTMVFKP	SDVMLVHFRN	VDEFNYATKDK	
Consensus	L--DA-H-K-	-E---GP-RE	-I-----FK-	SD---V-F--	-D--YA--D-	
Ataxin-2	200					

FIG. 7A

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					201	FTDSAIS. .A KVNGEHKEKD LEPWDAGELT ANEELEALEN DVSNWGWPND	250
Ataxin-2	FTDSAIS. .A KVNGEHKEKD LEPWDAGELT ANEELEALEN DVSNWGWPND						
Mouse Ataxin-2	FTDSAIS. .A KVNGEHKEKD LEPWDAGELT ANEELE.LEN DVSNWGWPND						
A2RP	FTDSAIAMNS KVNGEHKEKV LQRWEGGD.S NSDDYD.LES DMSNWGWPNE						
Consensus	FTDSA----- KVNGEHKEK- L--W--G--- -----LE- D-SNGWDPN-						
					251	MFRYNEENYG VVSTYDSSL S SYTVPLERDN SEEFLKEAR ANQLAEEIES	300
Ataxin-2	MFRYNEENYG VVSTYDSSL S SYTVPLERDN SEEFLKEAR ANQLAEEIES						
Mouse Ataxin-2	MFRYNEENYG VVSTYDSSL S SYTVPLERDN SEEFLKEAR ANQLAEEIES						
A2RP	MFKFNEENYG VKTITYDSSL S SYTVPLEKDN SEEFRQRELR AAQLAREIES						
Consensus	MF--NEENYG V-.TYDSSL S SYTVPLE-DN SEEF--RE-R A-QLA-EIES						
					301	SAQQYKARVAL ENDD.RSEE E KYTAVQRNS S EREGHSINTR ENKYIPPGQR	350
Ataxin-2	SAQQYKARVAL ENDD.RSEE E KYTAVQRNC S DREGHGPNT R DNKYIPPGQR						
Mouse Ataxin-2	SPQYRLRIAM ENDDGRTEEE KHSAVQRQGS GRESPLASR EGKYIP...						
A2RP	S-QY--R-A- ENDD-R-EEE K--AVQR--S -RE-----R --KYIP----						
Consensus	Consensus --						
					351	Ataxin-2 NR	
						Mouse Ataxin-2 NR	
						A2RP ..	
						Consensus --	

FIG. 7B

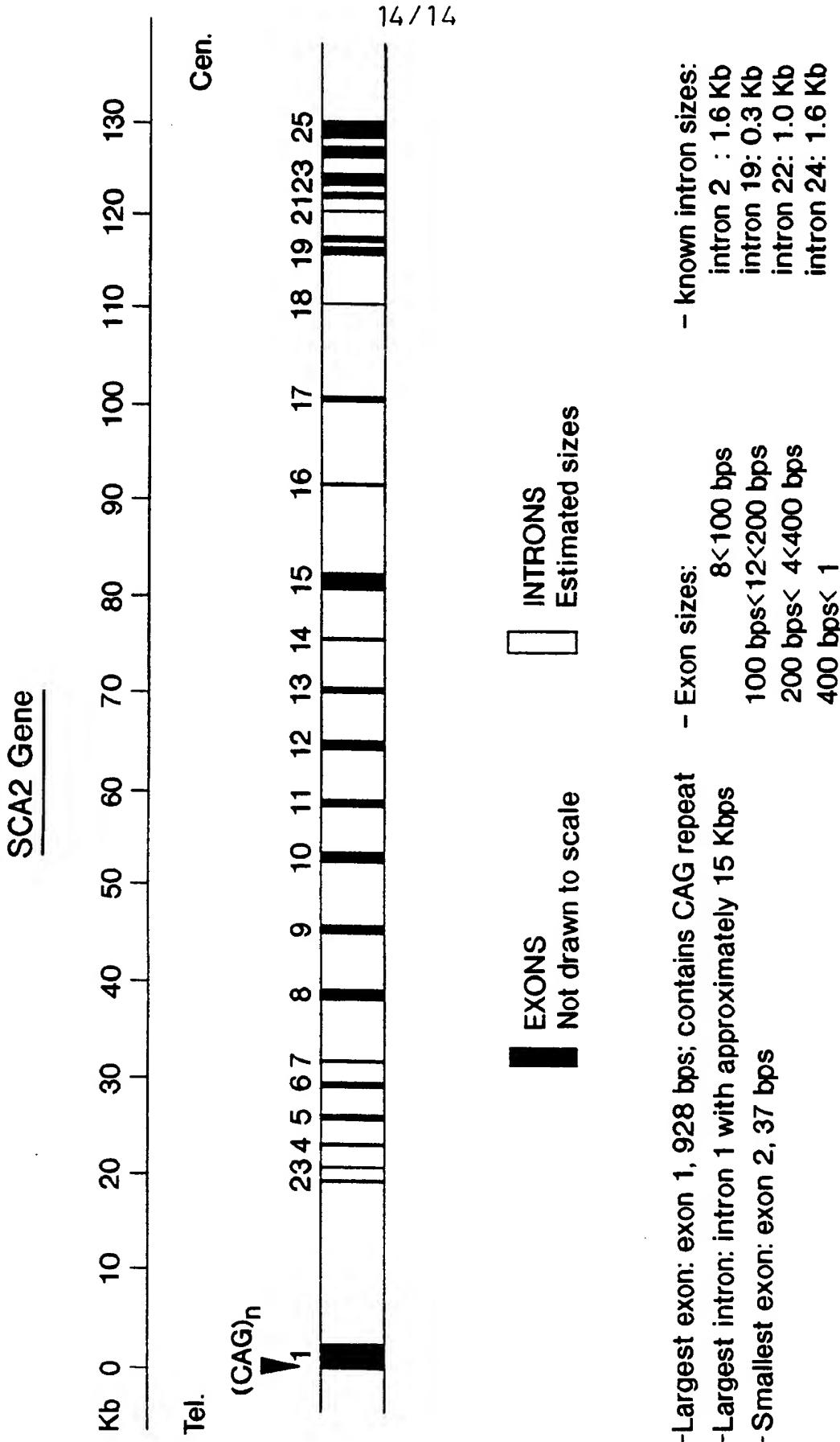


FIG. 8

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 97/07725

- 1 -

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6	C12N15/00	C12N15/12	C12N5/10	C07K14/47	C07K16/18
	C12Q1/68	G01N33/577	A01K67/027		

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C12N C07K C12Q G01N A01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	<p>WO 97 17445 A (CENTRE NAT RECH SCIENT ;INST NAT SANTE RECH MED (FR); TORA LAZSLO) 15 May 1997 see page 18, line 25 - page 21, line 14 ---</p>	1-30, 37-43
X	<p>NATURE, vol. 378, no. 6555, 23 November 1995, pages 403-406, XP002009617 TROTTIER Y ET AL: "POLYGLUTAMINE EXPANSION AS A PATHOLOGICAL EPITOPE IN HUNTINGTON'S DISEASE AND FOUR DOMINANT CEREBELLAR ATAXIAS" see the whole document ---</p> <p style="text-align: right;">-/--</p>	24,25,39

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

28 August 1997

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Hornig, H

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 97/07725

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	NEUROLOGY, vol. 45, no. S4, April 1995, MINNEAPOLIS, US, page A422 XP002039148 S.-M. PULST ET AL.: "Genetic and physical map of the spinocerebellar ataxia 2 (SCA2) region on human chromosome" abstract no. 931S see abstract ---	1-43
A	WO 95 01437 A (UNIV MINNESOTA) 12 January 1995 see the whole document ---	1-43
P,X	HUMAN MOLECULAR GENETICS, vol. 5, no. 12, December 1996, pages 1887-1892, XP002027564 STEVANIN G ET AL: "SCREENING FOR PROTEINS WITH POLYGLUTAMINE EXPANSIONS IN AUTOSOMAL DOMINANT CEREBELLAR ATAXIAS" see the whole document ---	24,25,39
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Information on patent family members

International Application No

PCT/US 97/07725

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